



**2019** R.B. ANNIS WATER  
RESOURCES INSTITUTE

# 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.



**GRAND VALLEY  
STATE UNIVERSITY**

ROBERT B. ANNIS  
WATER RESOURCES INSTITUTE



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## 2019: NIMBLE AND FOCUSED

Whether you recreate, navigate, activate, or meditate on the water bodies in Michigan, you have a vested interest in their welfare. Yet, seemingly every week, there is a new crisis facing our water resources: water levels (currently too high but only 7 years ago, people complained they were too low); PFAS; invasive species; microplastics; harmful algal blooms; excess lead in our drinking water—need I go on?

It is easy to become overly alarmed or fatigued by the barrage of announcements claiming impending disaster. These and other threats, real or imagined, need to be addressed by rigorous scientific investigation to better understand their scope and credibility.

At the Robert B. Annis Water Resources Institute (AWRI), we are using both traditional and innovative approaches to study these issues. Our goal is to provide the most robust scientific information to natural resource managers, decision makers, and the public, so they can make the most informed decisions possible when it comes to our water resources.

Some brief examples, which are described in more detail in the following pages, include:

- The Muskegon Lake Observatory Buoy, overseen by Dr. Bopi Biddanda, generates near real-time water quality data in Muskegon Lake; these data have shown the regular occurrence of very low dissolved oxygen concentrations (mischaracterized in the media as “dead zones”) in a large area of Muskegon Lake each summer. What are the ecological implications? Bopi and his students are investigating.
- A new invasive species, a submerged plant called Starry Stonewort, is making itself known in inland lakes throughout Michigan. Both Dr. Mark Luttenton and Dr. Sarah Hamsher are investigating its growth and how it can be controlled, but in different lakes; read on to see which lakes and their research activities.
- Dr. Carl Ruetz and his students are studying the viability of re-introducing Arctic Grayling, a once abundant fish, to Michigan streams and rivers. There are philosophical and policy implications to this re-introduction, but the issue is moot if the fishes can't be successfully introduced. See what they've discovered.

As you read the 2019 Year in Review, please note the breadth of topics that we cover at AWRI. They range from the genetic variation in baby's breath (yes, the flower found in wedding bouquets) to providing Michigan farmers almost instantaneous feedback as to whether their irrigation water is contaminated with virulent *E. coli* strains. To provide the scientific capacity to solve this breadth of challenges, we must remain nimble, adaptable, and focused in our work. The challenges facing our water resources demand that our science be rigorous, relevant, and reliable, and we take that charge seriously.

Finally, let us not forget that one of our core missions is to educate the water stewards of the future. We do this at the K-12, undergraduate, and graduate levels, ensuring that these students have the necessary training and education to eventually fill our shoes, and solve whatever new problems emerge in the future.



Alan Steinman  
Allen and Helen Hunting Director, AWRI



Dr. Alan Steinman,  
The Allen and Helen Hunting Director



Rick Rediske (left), Janice Tompkins, A.J. Birkbeck,  
and Lynn McIntosh at the Rockford tannery site.  
Photo Credit: Rex Larsen, *Science* Magazine.

## REDISKE FEATURED IN *SCIENCE* MAGAZINE

The story of Rockford, Michigan groundwater pollution due to PFAS (a class of synthetic fluorinated chemicals) has received national and international attention. AWRI's Rick Rediske has been at the forefront of the story; his role with the citizen group fighting corporate and government denial of the problem was featured this year in *Science* magazine. Dr. Rediske became involved with the group in 2012, giving scientific expertise and serving as an expert witness for journalists, community groups, and a U.S. Congressional field hearing. More information about PFAS and Rick's work can be found at [www.gvsu.edu/pfas](http://www.gvsu.edu/pfas).

## AWRI ARTIST LEAVES A LEGACY



Artist Charles (Larry) Laurens Heald (1940-2019), creator of “Reflections on Water”, a featured painting in AWRI's Lake Michigan Center, passed away on October 1, 2019. Heald was a relative of D.J. Angus, whose donation of GVSU's first research vessel was instrumental to AWRI's founding.

## AWRI BUOY'S NINTH YEAR



For the ninth consecutive year, the Muskegon Lake Observatory Buoy has been successfully operated in Muskegon Lake providing high-resolution time-series data on weather and water quality, thanks to support from the Community Foundation for Muskegon County and the Charles Edison Fund. AWRI can now closely track the annual rise and fall of eutrophication, hypoxia, and harmful algal blooms in Muskegon Lake and study their causes and consequences in detail. [www.gvsu.edu/buoy](http://www.gvsu.edu/buoy)

Graduate student Jasmine Mancuso (left) and technician Tony Weinke (right) prepare the GVSU Observatory for lake deployment in May 2019.





## IN SEARCH OF WHAT TRIGGERS HARMFUL ALGAL BLOOMS

Harmful algal blooms (HABs) are generally dominated by toxic, nuisance species of cyanobacteria (blue-green algae) and are globally increasing in frequency, duration, and intensity. Increased nutrient inputs (mainly from agricultural and urban fertilizer use) and warmer temperatures stimulate HABs, which link them to anthropogenically-induced climate and land use change. HABs threaten humans and wildlife via their potential toxicity, impacts to the ecosystem and food web, and deterioration of water quality. Drinking water problems, beach closings, and fish kills are all possible outcomes of HABs, and it is important to understand what environmental factors contribute to their proliferation. Muskegon Lake, a Great Lakes Area of Concern since 1985, experiences annual HABs. With data collected from the Muskegon Lake Observatory Buoy, field sampling, and *in situ* bioassay experiments, the Biddanda Lab aims to better understand HAB dynamics and to generate potential management and mitigation strategies.

Graduate student Jasmine Mancuso is studying the dynamics of cyanobacterial HABs (green surface streaks in photo) in Muskegon Lake.

## LAKE HURON'S SINKHOLES AS A MODEL FOR EXTREME LIFE

An otherworldly lakescape composed exclusively of microbial life prevails at the bottom of the Middle Island Sinkhole in Lake Huron. Here, under cold water temperatures (~9°C) and dim sunlight (only ~5% of which reaches the ~25 m deep sinkhole), a dynamic mosaic of cyanobacterial (purple) and chemosynthetic (white) mats flourish in groundwater containing high-sulfur and low-oxygen.

Underwater lakescape of the Middle Island Sinkhole, Lake Huron in June 2019. Photo Credit: Phil Hartmeyer, NOAA.



## EPISODIC STORMS AND LAKE HYPOXIA

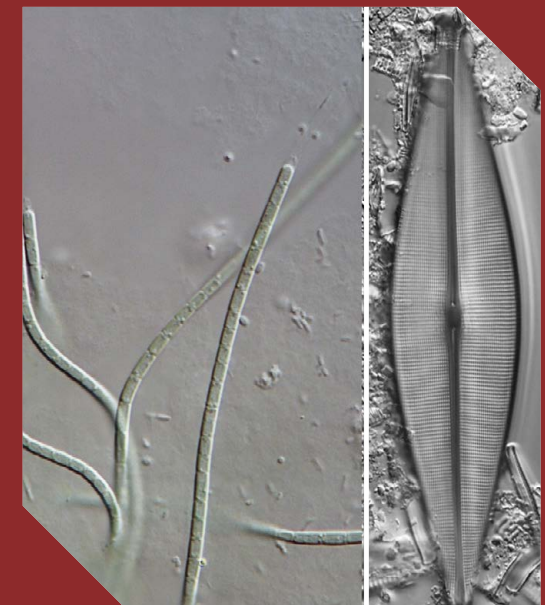
When summer temperatures heat up, lakes often stratify with warmer water near the surface and cooler water near the bottom. Consequently, atmospheric oxygen cannot penetrate to the bottom waters, resulting in low oxygen levels (hypoxia). Time-series weather and water quality data from Muskegon Lake revealed that episodic storms may influence how long hypoxia lasts and where hypoxic waters move in the lake. High winds may cause nutrient-rich hypoxic bottom waters to mix with the surface, inducing algal blooms.

The Muskegon Lake Observatory Buoy monitors changes in water quality conditions throughout the water column.



## CYANOBACTERIA AND DIATOMS OF SUBMERGED SINKHOLES IN LAKE HURON

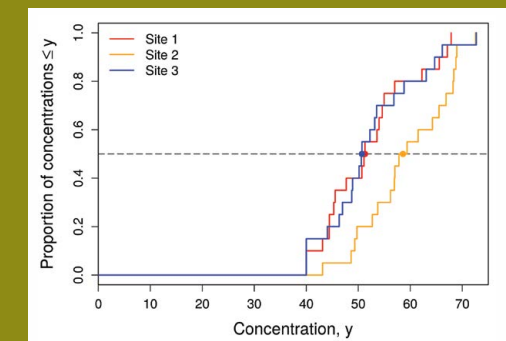
Low-oxygen, high-sulfur submerged sinkholes in Lake Huron that are home to many species of diatoms and cyanobacteria may resemble habitats found on early Earth. Diatoms, the most diverse group of microalgae, are responsible for 40% of the planet's carbon-cycling and have glass-like cell walls. Cyanobacteria are amongst the oldest known organisms (>3.5 billion years old) and are responsible for 40% of planetary oxygen production. Cyanobacteria also produce many unique compounds, some of which may be explored as new antibiotics or novel bio-pharmaceutical products. The Hamsher Lab and research collaborators in Florida are working to identify and characterize the diatoms and cyanobacteria found in these fascinating sinkholes. To date, 12 unique cyanobacteria and at least two species of diatoms have been recovered. Further examination of DNA sequences of these cultures is underway and will be essential in identifying them as it is expected some of these species will be new to science.



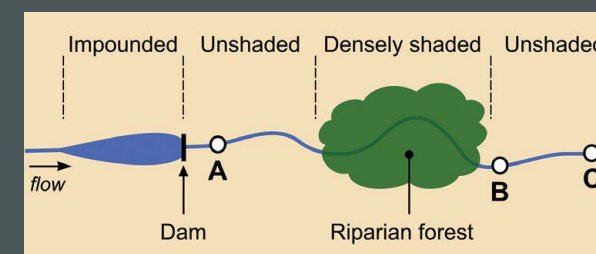
Microscopic images of a cyanobacterium, *Phormidium* sp. (left), and a diatom, *Craticula cuspidata* (right), isolated from the sinkhole in Lake Huron.

## STATISTICAL METHODS FOR CENSORED CONCENTRATIONS: IS IT OK TO MAKE UP DATA?

Many applied environmental studies involve the collection of field samples for chemical analysis. Often, a significant number of samples have concentrations too low for reliable measurement; it is only known that these concentrations are below the limit of quantification (LOQ) for the analytical method. Such left-censored data are not appropriate for traditional statistical methods, so how can the data be analyzed? The usual approach is to replace each censored observation with a value equal to half the LOQ, then apply traditional statistical methods to the edited data. But making up data is hardly statistically rigorous! Dr. Jim McNair, with faculty and graduate student collaborators from AWRI and GVSU's statistics program, is exploring an alternative approach to adapt methods from statistical survival analysis specifically designed for censored data. These methods provide all required types of statistical analyses (site comparisons, trend assessment, etc.) for concentration data in a completely rigorous manner and are now being utilized in AWRI projects.



Example of censored concentration data from different sampling sites using nonparametric survival analysis. The stair-case curves are Kaplan-Meier estimates of the cumulative distribution of concentrations for the three sites.



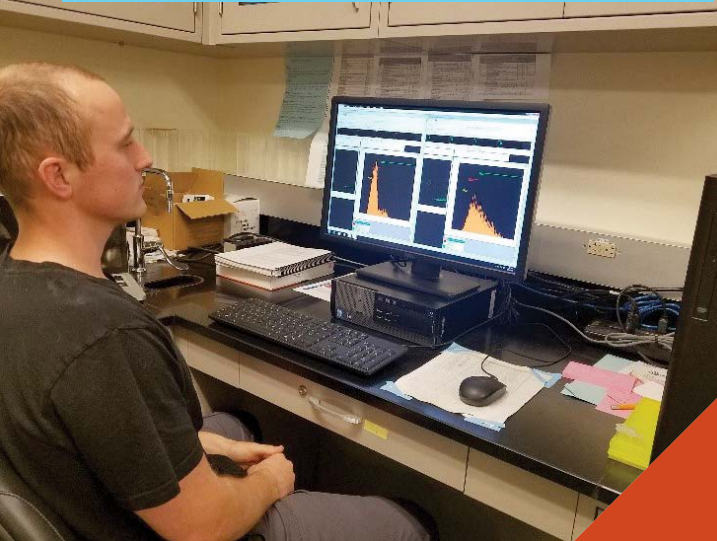
Do photosynthesis and respiration rates reflect the stream reach being sampled or the reach directly upstream of the sampling site? Would rates estimated at A mainly reflect the upstream impoundment or the unshaded reach? Would rates estimated at B mainly reflect the densely shaded forest habitat or the unshaded reach? How about rates estimated at C?

## ESTIMATING COMPONENTS OF STREAM METABOLISM WITH THE FREE-WATER DISSOLVED-OXYGEN METHOD: WHERE DID THE OXYGEN COME FROM?

The free-water dissolved-oxygen (DO) method is commonly used to estimate photosynthesis and respiration rates of stream communities, which measure overall stream function, and is useful in assessing human impacts. These estimates are inferred from DO time series-acquired data at one or more locations along a stream. But which upstream area primarily determines the DO measured at a given location? Which area is being assessed? Dr. Jim McNair is conducting field and modeling studies to explore this problem.



FOOD ALERT: MULTISTATE  
*E. coli* OUTBREAKS AFFECTING  
FRUITS, VEGETABLES, & MEAT



Over the past few years, multiple instances of *Escherichia coli* (*E. coli*) contamination and subsequent recalls of affected food products including lettuce, cheese, flour, and more recently ground beef and bison, have occurred nationwide. AWRI researcher Dr. Kevin Strychar received a Michigan Department of Agriculture and Rural Development (MDARD) grant to study agricultural safety in Michigan. MDARD's concerns include what would happen to Michigan's staple crops like apples, blueberries, and cherries if an *E. coli* outbreak caused children, adults, and/or the elderly to develop life-threatening infections. At AWRI, procedures using Imaging Flow Cytometry are being explored to rapidly detect such contamination in seconds as opposed to hours or days, which is the current processing time required by other methods.

Research assistant Darrick Gates is developing Imaging Flow Cytometry protocols to rapidly detect *E. coli* pathogens associated with agricultural food products. His promising results show detection in seconds to minutes versus traditional methods requiring hours or days.  
Photo Credit: Kevin Strychar.

THE EFFECTS OF CLIMATE  
CHANGE ON SHALLOW  
COLDWATER CORALS

Temperature increases associated with climate change cause corals to bleach, defined as the expulsion of their symbiotic algae leaving the coral white in color. With the impacts of climate change lurking over the next several decades, temperate corals also may be susceptible to these concerns, yet we know very little about them. In this study, graduate student Tyler Harmon is investigating how one cold water coral species, *Astrangia poculata*, will fare against temperature anomalies.

*Astrangia poculata*.  
Photo Credit: Kevin Strychar.



CLASSROOM PROGRAMS,  
WORKSHOPS, AND WATER  
FESTIVALS COMPLEMENT  
VESSEL PROGRAMS

The heart of AWRI's outreach program is the water quality sampling and analysis cruises onboard the *D.J. Angus* and the *W.G. Jackson* for grades 4 and up. Over 5,200 passengers were onboard in 2019 at our Grand Haven and Muskegon ports of call, in addition to a summer trip to Michigan City and Hammond, Indiana. Visitors on the vessels included guests from Poland and Chile as well as Great Lakes Stewardship Initiative teachers. Almost 2,000 students and adults participated in AWRI's education classroom, including K-12 programs, a Plankton Algae Workshop sponsored by the Michigan Chapter of the American Water Works Association, and an Aquaculture Workshop led by Dr. Barbara Evans from Lake Superior State University. AWRI staff participated in Earth Day events in Muskegon and Grand Haven, water festivals in Holland and Big Rapids, and the annual Grand Haven Salmon Festival.



Lead instructor Paula Capizzi (right) assists a Groundswell teacher on the *D.J. Angus*.

JOHNS HOPKINS  
STUDENTS VISIT AWRI

AWRI collaborated with the Cranbrook Institute of Science's Freshwater Forum to host students in Johns Hopkins University's Great Lakes Ecology and Management for Environmental Sciences and Policy course. The course examined physical, chemical, and biological aspects of the Great Lakes as well as governance, policy-making, and management through online lectures and nine days of field experiences in Michigan. During their AWRI visit, students received presentations by AWRI faculty and enjoyed a *W.G. Jackson* scientific cruise.



Johns Hopkins students on the *W.G. Jackson* with their instructor, Paul Kazyak (right).

ON THE BRINK OF EXTINCTION

On the brink of extinction, *Acropora cervicornis* is a reef building coral currently protected under the Endangered Species Act, as global warming has resulted in massive deaths of this species worldwide. Graduate student Cassidy Gilmore is studying whether three different growth conditions [(1) electrical impulse, (2) aquacultured, and (3) wild-caught] lead to stronger and more thermal-tolerant coral.

Bleaching *Acropora cervicornis* on the Great Barrier Reef.  
Photo Credit: Kevin Strychar.



NEW GROUNDWATER MODEL

As an addition to AWRI's outreach program, science instructor Penny Reid developed an activity using our new groundwater model, highlighting current groundwater issues in Ottawa County, including diminishing groundwater supplies and contamination issues.





## FUTURISTIC FILTERS FOR FARM FERTILIZER

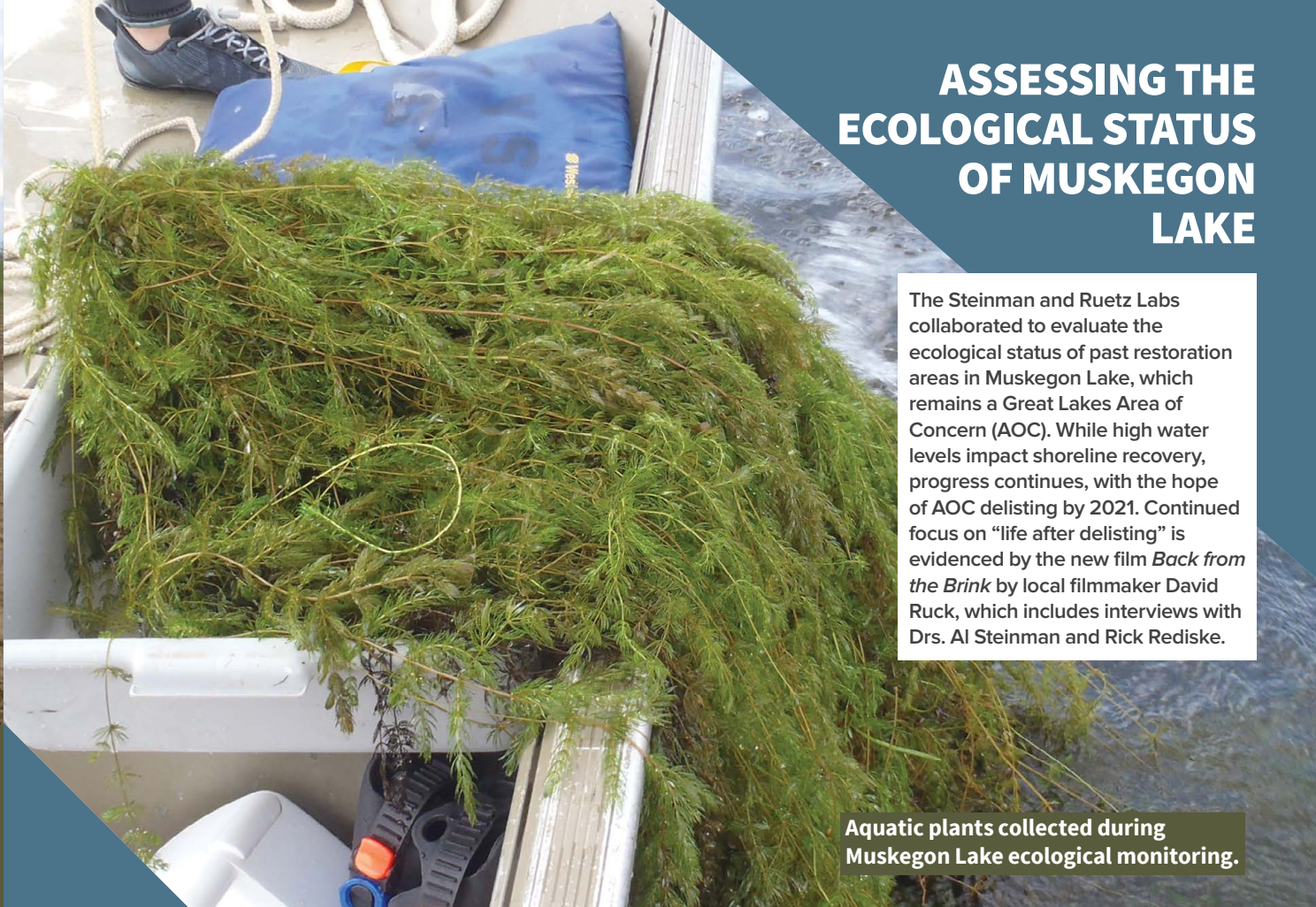
Tile drains are underground drainage systems that help move excess subsurface water from farm fields; however, this can also result in nutrients (including phosphorus) being transported from the fields out the tile drain and into agricultural ditches. This discharged phosphorus ultimately flows into downstream lakes, promoting algal blooms. New technologies are being explored that can filter the nutrients while in the tile drains before they are discharged to agricultural ditches. One such technology utilizes iron, which efficiently binds to phosphorus, as long as it stays in its oxidized form (that is, with oxygen present). The Steinman Lab, working in conjunction with the Outdoor Discovery Center Network in Holland and with funding from the Michigan Department of Agriculture and Rural Development, is testing the phosphorus binding effectiveness of iron slag filters at various sites in the Macatawa Watershed. This is part of Project Clarity's overall efforts to reduce phosphorus loads into Lake Macatawa.



Research assistant Rachel Orzechowski analyzing tile drain water from an underground iron slag filter.

## ASSESSING THE ECOLOGICAL STATUS OF MUSKEGON LAKE

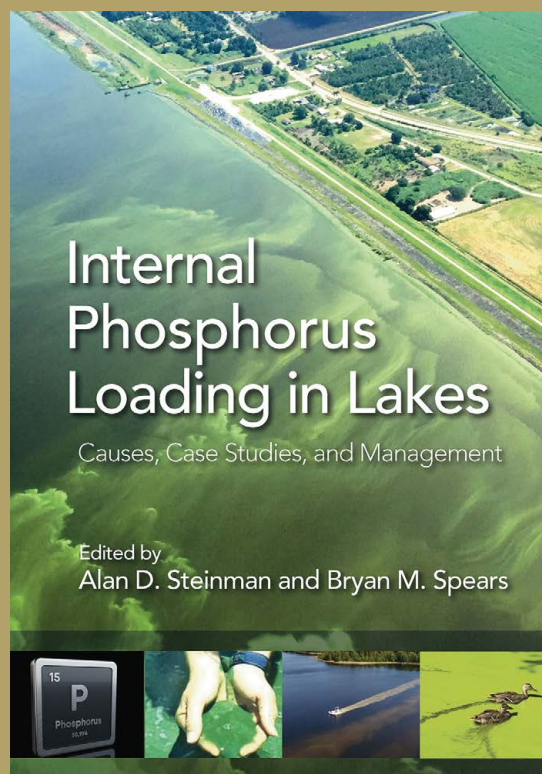
The Steinman and Ruetz Labs collaborated to evaluate the ecological status of past restoration areas in Muskegon Lake, which remains a Great Lakes Area of Concern (AOC). While high water levels impact shoreline recovery, progress continues, with the hope of AOC delisting by 2021. Continued focus on "life after delisting" is evidenced by the new film *Back from the Brink* by local filmmaker David Ruck, which includes interviews with Drs. Al Steinman and Rick Rediske.



Aquatic plants collected during Muskegon Lake ecological monitoring.

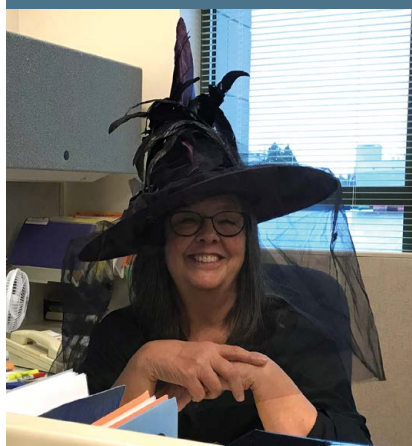
## PROSPEROUS PARTNERSHIP PRESENTS PUBLICATION

Al Steinman and collaborator Bryan Spears at the United Kingdom's Centre for Ecology & Hydrology co-edited a new book titled *Internal Phosphorus Loading in Lakes: Causes, Case Studies, and Management*. AWRI adjunct research assistant Emily Kindervater aided in editorial duties and co-authored a book chapter with Dr. Steinman and former technician Nicole Hahn.



## FAREWELL, PAULA!

Paula Wicklund, AWRI's Office Coordinator for the past nine years, retired this past Halloween. We're sad to see her go but send her our best wishes as she sashays her way into retirement. She plans to spend more time with family, catch movies at the theater, and spoil her cat Sheba.



## AWRI DIRECTOR RETURNS TO CHINA



Al Steinman was invited to provide the kick-off presentation at the "First Forum on Aquatic Ecosystem Restoration and Health" at the Sino-Danish Center for Education and Research in Beijing. Steinman spoke about his new book co-edited with Bryan Spears on internal phosphorus loading in lakes around the world, as well as research his lab has been doing on internal phosphorus loading in lakes around west Michigan.





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## AWRI AT WORK

- 1 Graduate student Jasmine Mancuso (left) and technician Tony Weinke (right) on Muskegon Lake.
- 2 Intern Ian Stone (left), graduate student Katie Knapp (center), and Dr. Bopi Biddanda (right) at the Muskegon Lake Observatory buoy.
- 3 Research assistant Rachel Orzechowski setting invertebrate traps.
- 4 Graduate student Tyler Harman (left) and research assistant Darrick Gates (right) test SCUBA gear.
- 5 Graduate student Megan Mader and a snapping turtle.
- 6 Research assistant Travis Ellens (left), undergraduate assistant Alexis Hoskins (center), and technician Zak Collins (right) sample invertebrates.
- 7 Dr. Charlyn Partridge (left) and graduate student Sarah Lamar's (right) USA road trip collecting baby's breath samples.
- 8 Research assistant Emily Kindervater celebrating the end of a cold field day.
- 9 Research assistants Maggie Oudsema (left) and Rachel Orzechowski (right) dredge a pond.
- 10 Dr. Sarah Hamsher identifies algae for a workshop.
- 12 Science instructor Jamie Cross displays a Florel-Ule water quality scale.



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## SEQUENCING THE BABY'S BREATH GENOME



**Baby's Breath flowers.**  
Photo Credit: Sarah Lamar.

Invasive species are a threat to biodiversity as they can displace native species and alter ecosystems. The Partridge Lab is investigating how molecular mechanisms contribute to the ability of non-native species rapidly adapting to novel habitats. The lab is examining invasive baby's breath populations (*Gypsophila paniculata*) in Michigan sand dunes and Washington sagebrush steppes to evaluate how the populations cope in these different environments. Dr. Charlyn Partridge sequenced the genome of a baby's breath individual from Petoskey, Michigan, using PacBio Sequencing Technology. This produced 60x sequencing coverage, meaning that with an estimated genome size of 700 Mb (Mega bases), she collected over 4.9 billion bases of data! The next steps are to assemble and annotate the genome. This will serve as a reference genome to look at distinct genetic differences between populations, and help determine the unique selective pressures invasive plant populations face in the Michigan coastal dune ecosystem.

## COMMUNITY SERVICE FOR PFAS-IMPACTED COMMUNITIES



Per- and polyfluoroalkyl substances (PFAS) are a group of 4,000+ synthetic chemicals that have received national attention due to their persistence and potential for adverse human and environmental health impacts. Dr. Rick Rediske continues to provide technical assistance for environmental organizations and communities that are concerned about the adverse effects of PFAS. His work with a local citizen group was recognized in the journal *Science* for uncovering waste disposal practices by a tannery that resulted in a 25 square mile area of PFAS contamination with over 1,000 impacted residential wells. He also provided testimony at a U.S. Senate field hearing for Senator Gary Peters concerning the impact of PFAS on the environment and human health. Dr. Rediske helped found the Wolverine Community Advisory Group and serves as co-chair. This organization provides stakeholder input to the cleanup and restoration of the tannery and land disposal sites.

**Dr. Rediske (far right) at the U.S. Senate PFAS field hearing.**

## THE ART OF THE ROUND GOBY



Partridge Lab summer students, Steve Smit (top) and Alex Florian (bottom), evaluated the presence of male alternative reproductive tactics (ARTs) in invasive round gobies (*Neogobius melanostomus*). They found that sneaker males (smaller males that sneak past larger nest-guarding males to fertilize eggs) make up roughly 20% of the reproductive male population during the summer.

## USING eDNA TO DETECT HEMLOCK WOOLLY ADELGID



**White woolly egg sacs produced by HWA on a hemlock tree branch.**  
Photo Credit: U.S. Forest Service.

The Partridge Lab received funding from the U.S. Forest Service to develop airborne eDNA technology to aid in early monitoring of Hemlock Woolly Adelgid (HWA). HWA is an invasive insect that threatens the health of hemlock forests. Unfortunately, populations have been confirmed in areas around West Michigan. The addition of this technology for natural resource managers will lead to earlier detection of this invasive pest, while preserving valuable resources for HWA treatment and eradication efforts.



## GEOMORPHIC AND BIOLOGICAL SURVEYS IN LITTLE FLOWER CREEK

The Rediske Lab conducted bioassessments of fish and benthic macroinvertebrate communities and surveyed streambank conditions in Little Flower Creek (Oceana and Muskegon Counties) to prioritize restoration areas to reduce sediment loading to the creek in the restoration of this coldwater fishery.

**Intern Mason Tolonen (left) and undergraduate assistant Noah Cleghorn (right) assessing Little Flower Creek streambanks.**

## AWRI IMPLEMENTS qPCR METHODS FOR HUMAN DNA MARKERS FOR BEACH MONITORING

AWRI expanded its DNA-based beach monitoring to include human biomarkers. Current testing involves measuring *E. coli*, a generic intestinal bacterium in warm-blooded animals. Using human biomarkers, the Rediske Lab is able to determine the presence of human waste in beach water samples when high levels of *E. coli* are found. They are also in the process of implementing genetic marker testing for cows, birds, and swine.

**Undergraduate assistant Noah Cleghorn conducts beach monitoring for *E. coli*.**





## GETTING TO THE BOTTOM OF HIGGINS LAKE



Higgins Lake is regarded for high water quality and is a premier recreational destination. Although spectacular from the surface, historic data from the 1930s suggest that it has been subject to significant ecological impacts beginning with the logging era. Studies conducted since the 1970s suggest nutrient additions have slowly been pushing Higgins Lake toward long-term changes including extensive weed growth and a significant accumulation of thick organic sediments typical of more nutrient-rich lakes.

The introduction of aquatic invasive species (AIS) into inland lakes is a major concern for resource managers. During recent surveys of the Higgins Lake watershed, Dr. Mark Luttenton cataloged five invasive mollusks, including zebra and quagga mussels, and seven invasive plant species, including starry stonewort, which have spread across the watershed.

**Starry stonewort, zebra and quagga mussels from Higgins Lake.**

## STAR WARS: A STUDY OF STARRY STONEWORT IN PENTWATER LAKE



Emily Neuman, a new graduate student working with Dr. Sarah Hamsher, snorkels in Muskegon Lake to collect aquatic plants and macroalgae. Emily will examine the growth of the invasive macroalga starry stonewort (*Nitellopsis obtusa*) in Pentwater Lake.

## AWRI WELCOMES DR. SEAN WOZNICKI!

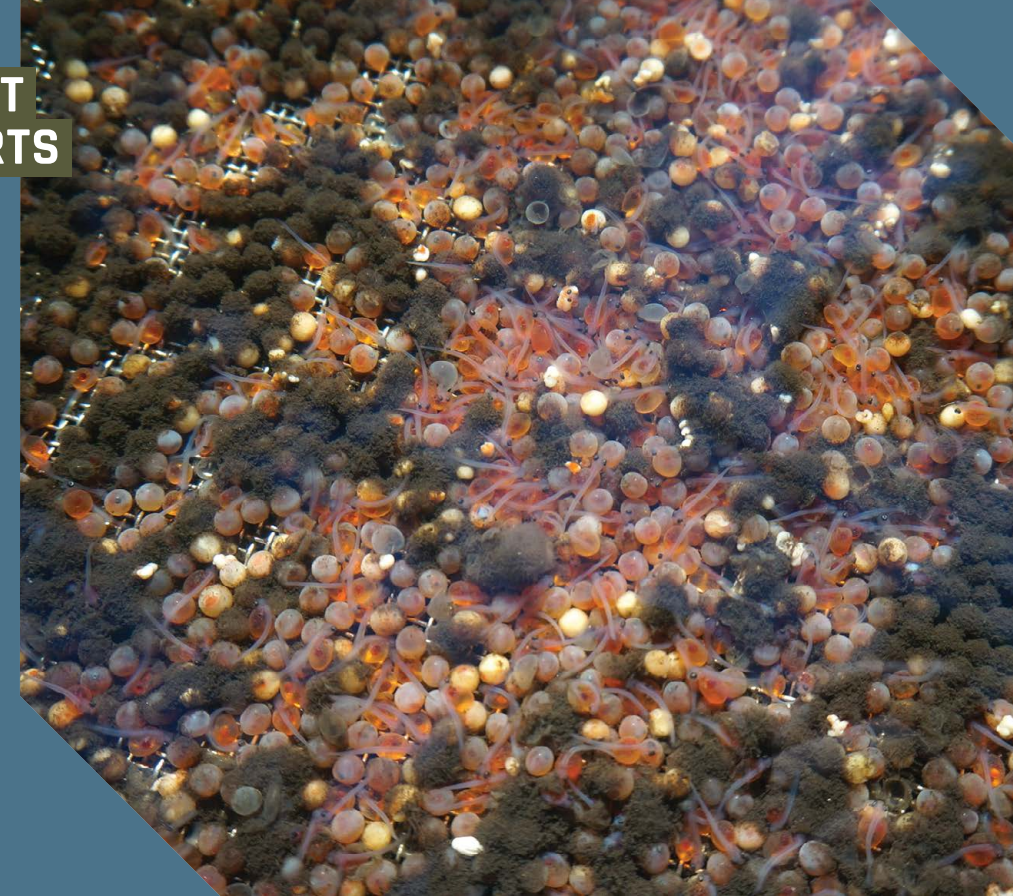
Dr. Sean Woznicki joined AWRI this fall as an Assistant Professor specializing in watershed hydrology and geospatial ecology. Sean comes to us from the U.S. Environmental Protection Agency, where he mapped ecosystem services at scales ranging from headwater watersheds to the continental USA. His ongoing research tracks how climate change, urbanization, and agriculture alter the hydrology and water quality of rivers and streams by using watershed modeling, geospatial analysis, remote sensing, and long-term environmental monitoring.

**Dr. Woznicki assisting with Muskegon Lake long-term monitoring on the *W.G. Jackson*.**



## GRADUATE STUDENT RESEARCH SUPPORTS ARCTIC GRAYLING RESTORATION

Alan Mock, a graduate student working with Dr. Carl Ruetz, conducted field experiments to assess the feasibility of using streamside egg incubators to support the reintroduction of Arctic grayling to Michigan streams, which were extirpated from Michigan in the early 1900s. Streamside incubators were used to successfully re-establish Arctic grayling in Montana, which has led to renewed interest in restoring Michigan's population. Alan evaluated streamside incubators in Manistee River tributaries using rainbow trout eggs as surrogates for Arctic grayling and showed that these incubators can be used successfully in Michigan streams. His research will help state and tribal agencies in their effort to re-introduce Arctic grayling in Michigan. Since graduating, Alan started a PhD program at Florida International University in Miami.



**Rainbow trout eggs and fry inside a streamside incubator (top).**



**Graduate student Alan Mock records data during a field experiment (left).**

## AWRI ASSISTS WITH LAKE STURGEON CONSERVATION



**Juvenile lake sturgeon held at AWRI during Muskegon River lampricide treatment. Photo Credit: Amanda Pitts, GVSU.**

Management strategies for invasive species occasionally conflict with native species conservation. Native lake sturgeon were once abundant in Michigan but were nearly extirpated by the late 1800s. A remnant population spawns in the Muskegon River, which is periodically treated with a lampricide to control invasive sea lamprey. Unfortunately, the lampricide can be harmful to juvenile lake sturgeon. The Little River Band of Ottawa Indians worked with AWRI to hold juvenile lake sturgeon in AWRI's mesocosm tanks during a recent lampricide treatment of the Muskegon River. The juvenile lake sturgeon were released unharmed following the lampricide application.



# AWRI FACULTY & STAFF

## THE ALLEN AND HELEN HUNTING DIRECTOR:

Alan Steinman, Professor

## STAFF/ADMINISTRATIVE:

Tonya Brown, AWRI Assistant  
Brittany Preston, Student Clerical Assistant  
Roxana Taylor, Secretary  
Paula Wicklund, Office Coordinator  
(retired: October 2019)

## FACILITIES/MAINTENANCE:

Len Wittlieff, Maintenance

## INFORMATION SERVICES CENTER:

Sean Woznicki, Assistant Professor

## OUTREACH & EDUCATION:

Janet Vail, Research Scientist  
Paula Capizzi, Lead Instructor DJA  
Jamie Cross, Science Instructor  
Kellie Decker, Intern (Lake Superior State University)  
Cheri Gerhart, Science Instructor  
Ann Hesselsweet, Science Instructor  
Tom Jackson, Science Instructor  
Shirley McIntire, Science Instructor  
Maggie Pinjuv, Science Instructor  
Lindsey Piper, Intern (N. Muskegon High School)  
Penny Reid, Science Instructor  
Michele Smith, Science Instructor  
Amanda Syers, Science Education Specialist  
Diane Veneklasen, Science Instructor  
Chloe Wolffis, Intern (N. Muskegon High School)

## GVSU VESSELS/FLEET OPERATIONS:

Anthony Fiore, Jr., Fleet Captain  
Terry Boersen, Deckhand WGJ  
John Bontrager, Relief Captain WGJ  
Dave Fisher, Marine Engineer WGJ  
Mitch Gingras, Deckhand DJA/WGJ  
Tim Halloran, Deckhand WGJ  
Roger Haynor, Lead Captain DJA  
Eric Hecox, Lead Captain WGJ and Relief Captain DJA  
Pete Hewett, Engineer DJA  
Tim Lucas, Relief Captain DJA  
Brad Nieboer, Marine Electrician  
Jim Rahe, Deckhand WGJ  
Peter Stoeckle, Deckhand DJA

## ECOLOGICAL RESEARCH, ENVIRONMENTAL CHEMISTRY:

Richard Rediske, Professor  
Noah Cleghorn, Undergraduate Student Assistant  
Yingqing Deng, Aquatic Environmental Chemist  
Postdoctoral Researcher  
Molly Lane, Adjunct Research Assistant  
Igor Mrdjen, Aquatic Environmental Chemist  
Postdoctoral Researcher  
Brian Scull, Laboratory Supervisor

## ECOLOGICAL RESEARCH, ENVIRONMENTAL BIOLOGY:

Bopaiah Biddanda, Professor  
Scott Kendall, Technical Call-in  
Anthony Weinke, Technical Call-in  
Sarah Hamsher, Assistant Professor  
Mark Luttenton, Professor of Biology  
Jim McNair, Associate Professor  
Charlyn Partridge, Assistant Professor  
Syndell Parks, Technical Call-in  
Carl Ruetz III, Professor  
Bert Carey, Technical Call-in  
Zakery Collins, Technical Call-in  
Alexis Hoskins, Undergraduate Student Assistant  
Trent Kehoe, Undergraduate Student Assistant  
Victoria Ostrander, Undergraduate Student Assistant  
Nick Proefke, Undergraduate Student Assistant  
Travis Ellens, Adjunct Research Assistant  
Alan Steinman, Professor  
Aaron Dunnuck, Adjunct Research Assistant  
Michael Hassett, Scientific Technician  
Emily Kindervater, Adjunct Research Assistant  
Rachel Orzechowski, Adjunct Research Assistant  
Maggie Oudsema, Research Assistant  
Kurt Thompson, Research Associate  
Kevin Strychar, Professor  
Darrick Gates, Adjunct Research Assistant

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Dr. Don Scavia, University of Michigan

## GRADUATE STUDENTS:

Biddanda, major advisor  
Katie Knapp  
Jasmine Mancuso, AWRI Assistantship  
Hamsher, major advisor  
Emily Neuman, AWRI Assistantship  
Luttenton, major advisor  
Barney Boyer, AWRI Assistantship  
Billy Mulligan, AWRI Assistantship  
Partridge, major advisor  
Ben Giffin  
Sarah Lamar, AWRI Assistantship  
Andrew Pyman  
Rediske, major advisor  
Matthew Allen, AWRI Assistantship  
Molly Lane, AWRI Assistantship  
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Travis Ellens  
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Paige Kleindl, AWRI Assistantship  
Katy Sheets, AWRI Assistantship  
Strychar, major advisor  
Eve Choi  
Cassidy Gilmore, AWRI Assistantship  
Tyler Harmon, AWRI Assistantship  
Jennifer Kovacs

# INTERNSHIPS & SCHOLARSHIPS

AWRI provides opportunities for students to pursue their interests in our environment. The following students received internships during 2019.

## HERBERT VANDERMEY INTERN:

Monica Van Til

## ROBERT B. ANNIS FOUNDATION INTERNS:

Sarrah Adamy  
Leona Addie  
Mason Tolonen

## AWRI INTERNS:

Ian Stone  
Autumn Taylor

## STEINMAN LAB INTERN:

Jane Johnston

## BILL AND DIANA WIPPERFURTH SCHOLARSHIP:

Christian Yap

## RON WARD SCHOLARSHIP:

Ethan Bach  
Shaina Jaster  
Emily Morrison  
Co Nguyen  
Ashley Teltow

## STUDENT SUMMER SCHOLAR (S3):

Alex Florian

## NOAA SUMMER INTERN:

Steve Smit



## PEER REVIEWED PUBLICATIONS

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

Aw, T.G., M. Sivaganesan, S. Briggs, E. Dreelin, A. Aslan, S. Dorevitch, A. Shrestha, N. Isaacs, J. Kinzelman, G. Kleinheinz, R. Noble, **R. Rediske**, **B. Scull**, S. Rosenberg, B. Weberman, T. Sivy, B. Southwell, S. Siefing, K. Oshima, and R. Haugland. 2019. Evaluation of multiple laboratory performance and variability in analysis of recreational freshwaters by a rapid *Escherichia coli* qPCR method (Draft Method C). *Water Research*, 156:465-474. doi: 10.1016/j.watres.2019.03.014

**Chorak, G.M.\*\***, **C.R. Ruetz III**, R.A. Thum, **C.G. Partridge**, D.J. Janetski, T.O. Höök, and D.F. Clapp. 2019. Yellow perch genetic structure and habitat use among connected habitats in eastern Lake Michigan. *Ecology and Evolution*. doi: 10.1002/ece3.5219

Cunha, A., **C.G. Partridge**, R. Knapp, and B.D. Neff. 2019. Androgen and prolactin manipulation induces changes in aggressive and nurturing behavior in a fish with male parental care. *Hormones and Behavior*, 116: 104582. doi: 10.1016/j.yhbeh.2019.104582

Dumke, J.D., **G.M. Chorak\*\***, **C.R. Ruetz III**, R.A. Thum, and **J.N. Wesolek**. In Press. Identification of black bullhead (*Ameiurus melas*) and brown bullhead (*A. nebulosus*) from the western Great Lakes: recommendations for small individuals. *American Midland Naturalist*.

**Gezon, N.R.\*\***, D.W. Haywick, J.M. Sanders, I. Hewson, and **K.B. Strychar**. In Press. Surveying the Circular Rep Encoding Single Stranded (CRESS) DNA viral consortium in quagga mussels (*Dreissena rostriformis bugensis*) and sediment from the central Lake Michigan benthos. *Journal of Great Lakes Research*.

**Hamsher, S.E.**, K.G. Keepers, C.S. Pogoda, J.G. Stepanek, N.C. Kane, and J.P. Kocielek. 2019. Extensive chloroplast genome rearrangement amongst three closely related *Halophora* spp. (Bacillariophyceae), and evidence for rapid evolution as compared to land plants. *PLoS ONE*, 14(7): e0217824. doi: 10.1371/journal.pone.0217824

Harrison, A.M., A.J. Reisinger, M.J. Cooper, V.J. Brady, J.J.H. Ciborowski, K.E. O'Reilly, **C.R. Ruetz III**, D.A. Wilcox, and D.G. Uzarski. 2019. A basin-wide survey of coastal wetlands of the Laurentian Great Lakes: development and comparison of water quality indices. *Wetlands*. doi: 10.1007/s13157-019-01198-z

Hopkins, K.G., A.S. Bhaskar, **S.A. Woznicki**, and R.M. Fanelli. In Press. Changes in event-based streamflow magnitude and timing after suburban development with infiltration-based stormwater management. *Hydrological Processes*. doi: 10.1002/hyp.13593

**Kindervater, E.\*\***, **N. Hahn\***, and **A.D. Steinman**. In Press. A meta-analysis of internal loading studies. In: **A.D. Steinman** and B.M. Spears (Eds.), *Internal phosphorus loading: Causes, case studies, and management* (pp. 433-444). Plantation, FL: J. Ross Publishing.

**Kindervater, E.\*\*** and **A.D. Steinman**. 2019. Two-stage agricultural ditch sediments act as phosphorus sinks in West Michigan. *Journal of American Water Resources Association*. 55(5): 1883-1195 doi: 10.1111/1752-1688.12763

Kovacs, D., **R. Rediske**, S. Marty, P. Spencer, D. Wilson, and B. Landenberger. 2019. Contemporary concepts in toxicology, a novel multi-instructor general education course to enhance green chemistry and biomedical curricula. *Green Chemistry Letters and Reviews*, 12:2, 136-146. doi: 10.1080/17518253.2019.1609600

Kovalenko, K.E., L.B. Johnson, V.J. Brady, J.J.H. Ciborowski, M.J. Cooper, J.P. Gathman, G.A. Lamberti, A.H. Moerke, **C.R. Ruetz III**, and D.G. Uzarski. 2019. Hotspots and bright spots in functional and taxonomic fish diversity. *Freshwater Science* 38(3):480–490. doi: 10.1086/704713

**Leimbach-Maus H.\*\***, **S.R. Parks**, and **C.G. Partridge**. 2018. Microsatellite primer development for the invasive perennial herb *Gypsophila paniculata* (Caryophyllaceae). *Applications in Plant Sciences*, 6(12): e1203. doi: 10.1002/aps3.1203

**Mrdjen, I.\*\***, M.A. Morse, R.J. Ruch, T.J. Knobloch, S. Choudhary, C.M. Weghorst, and J. Lee. 2018. Impact of Microcystin-LR on liver function varies by dose and sex in mice. *Toxins*, 10(11), pii: E435. doi: 10.3390/toxins10110435

**Myers, D.T.\*\***, **R.R. Rediske**, and **J.N. McNair**. 2019. Measuring streambank erosion: a comparison of erosion pins, total station, and terrestrial laser scanner. *Water*, 11(9):1846. doi: 10.3390/w11091846

**Rice, E.K.\*\***, P. Martinez-Oquendo, and **J.N. McNair**. 2019. Phenology of seed maturation in baby's breath (*Gypsophila paniculata*) in northwest Michigan, USA, and its relation to glyphosate efficacy. *Invasive Plant Science and Management*. doi: 10.1017/inp.2019.21

Rubbens, P., M.L. Schmidt, R. Props, **B.A. Biddanda**, N. Boon, W. Waegeman, and V.J. Denef. 2019. Randomized lasso links microbial taxa with aquatic functional groups inferred from flow cytometry. *mSystems*, 4(5): e00093-19. doi: 10.1128/mSystems.00093-19

Schock, N.T., A.J. Reisinger, L.S. Reisinger, M.J. Cooper, J.J.H. Ciborowski, T.M. Gehring, A.H. Moerke, **C.R. Ruetz III**, and D.G. Uzarski. 2019. Relationships between the distribution and abundance of the invasive faucet snail (*Bithynia tentaculata*) and environmental factors in Laurentian Great Lakes coastal wetlands. *Biological Invasions*, 21(8): 2613-2628. doi: 10.1007/s10530-019-02000-1

Sivaganesan, M., T.G. Aw, S. Briggs, E. Dreelin, A. Aslan, S. Dorevitch, A. Shrestha, N. Isaacs, J. Kinzelman, G. Kleinheinz, R. Noble, **R. Rediske**, **B. Scull**, S. Rosenberg, B. Weberman, T. Sivy, B. Southwell, S. Siefing, K. Oshima, and R. Haugland. 2019. Standardized data quality acceptance criteria for a rapid *Escherichia coli* qPCR method (Draft Method C) for water quality monitoring at recreational beaches. *Water Research*, 156: 456-464. doi: 10.1016/j.watres.2019.03.011

Smith, S.D.P., D.B. Bunnell, G.A. Burton Jr., J.J.H. Ciborowski, A.D. Davidson, C.E. Dickinson, L.A. Eaton, P.C. Esselman, M.A. Evans, D.R. Kashian, N.F. Manning, P.B. McIntyre, T.F. Nalepa, A. Pérez-Fuentetaja, **A.D. Steinman**, D.G. Uzarski, and J.D. Allan. 2019. Evidence for interactions among environmental stressors in the Laurentian Great Lakes. *Ecological Indicators*, 101: 203-211. doi: 10.1016/j.ecolind.2019.01.010

Spears, B. and **A.D. Steinman**. In Press. Synthesis, future avenues, and prospects. In: **A.D. Steinman** and B.M. Spears (Eds.), *Internal phosphorus loading: Causes, case studies, and management* (pp. 445-457). Plantation, FL: J. Ross Publishing.

**Steinman, A.D.** 2019. Response to Osgood Comment: Alum efficiency 11 years following treatment: Phosphorus and macroinvertebrates. *Lake and Reservoir Management*, 35(1): 4-7. doi: 10.1080/10402381.2018.1527797

**Steinman, A.D.** and B. Spears (Eds.). In Press. *Internal phosphorus loading in lakes: Causes, case studies, and management*. Plantation, FL: J. Ross Publishing.

**Steinman, A.D.** and B. Spears (Eds.). In Press. What is internal loading and why does it occur? In: **A.D. Steinman** and B.M. Spears (Eds.), *Internal phosphorus loading in lakes: Causes, case studies, and management* (pp. 3-13). Plantation, FL: J. Ross Publishing.

Strayer, D.L., B.V. Adamovich, R. Adrian, D.C. Aldridge, C. Balogh, L.E. Burlakova, H.B. Fried-Petersen, L.G. Tóth, A.L. Hetherington, T.S. Jones, , A.Y. Karatayev, J.B. Madill, O.A. Makarevich, J.E. Marsden, A.L. Martel, D. Minchin, T.F. Nalepa, R. Noordhuis, T.J. Robinson, L.G. Rudstam, A.N. Schwalb, D.R. Smith, **A.D. Steinman**, and J.M. Jeschke. 2019. Long-term population dynamics of dreissenid mussels (*Dreissena polymorpha* and *D. rostriformis*): a cross-system analysis. *Ecosphere*, 10(4): e02701. doi: 10.1002/ecs2.2701

**Su, X.\*\***, **A.D. Steinman**, **M. Oudsema**, **M. Hassett**, and L. Xie. 2019. The influence of nutrients limitation on phytoplankton growth and microcystins production in Spring Lake, USA. *Chemosphere*, 234: 34-42. doi: 10.1016/j.chemosphere.2019.06.047

Uzarski, D.G., D.A. Wilcox, V.J. Brady, M.J. Cooper, D.A. Albert, J.J.H. Ciborowski, N.P. Danz, A. Garwood, J.P. Gathman, T.M. Gehring, G.P. Grabas, R.W. Howe, L.B. Johnson, G.A. Lamberti, A.H. Moerke, G.J. Niemi, T. Redder, **C.R. Ruetz III**, **A.D. Steinman**, D.C. Tozer, and T.K. O'Donnell. 2019. Leveraging a landscape-level monitoring and assessment program for developing resilient shorelines throughout the Laurentian Great Lakes. *Wetlands*. doi: 10.1007/s13157-019-01139-w

Wan, X., **A.D. Steinman**, X. Shu, Q. Cao, L. Yao, and L. Xie. In Press. Combined toxic effects of microcystin-LR and phenanthrene on growth and antioxidant system of duckweed (*Lemna gibba* L.). *Ecotoxicology and Environmental Safety*, 185: 109668. doi: 10.1016/j.ecoenv.2019.109668

**Weinke, A.\*\***, and **B. Biddanda**. In Press. Influence of episodic wind events on thermal stratification and bottom water hypoxia in a Great Lakes estuary. *Journal of Great Lakes Research*.

**Yang, M.L.\***, **E. Rice\*\***, **H. Leimbach-Maus\*\***, and **C.G. Partridge**. 2019. Identification and characterization of *Gypsophila paniculata* color morphs in Sleeping Bear Dunes National Lakeshore, MI, USA. *PeerJ*, 7: e7100. doi: 10.7717/peerj.7100

## NON-PEER REVIEWED PUBLICATIONS

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

**Biddanda, B.** 2019. Who is observing the observatory? Postcards from the field. May 6, 2019. Eos, American Geophysical Union. <https://americangeophysicalunion.tumblr.com/post/184689338803/whos-observing-the-observatory-dear-eos>

**Biddanda, B.A.**, **J. Mancuso\*\***, **R. Ratliff\***, **K. Knapp\*\***, **A. Wienke\*\***, and M. Villar-Argaiz. 2019. Anthropocene: The uncertain age of humans. A book review of "Anthropocene: a very short introduction" by Earle C. Ellis. 2018. InterChange – Connections for the STEM Classroom, Newsletter of Regional Math and Science Center, GVSU. February 2019. <https://www.gvsu.edu/rmsc/interchange/2019-february-connections-1441.htm>

**Biddanda, B.**, **I. Stone\***, W. Lusardi, and P. Hartmeyer. Diving sinkholes for microbial mats that bury carbon and release oxygen. Postcards from the field. June 26, 2019. Eos, American Geophysical Union. <https://americangeophysicalunion.tumblr.com/post/185867706388/diving-sinkholes-for-microbial-mats-that-bury>

**Biddanda, B.** and **A. Weinke\*\***. 2019. Tracking triggers of harmful cyanobacterial blooms in an urbanized freshwater estuary. Postcards from the field. October 7, 2019. Eos, American Geophysical Union. <https://americangeophysicalunion.tumblr.com/post/188191410353/tracking-triggers-of-harmful-cyanobacterial-blooms>

**Dila, D.\*\*** and **B. Biddanda**. February 2019. Inventorying microbes in Lake Michigan. Postcards from the field. Eos, 100(2): 52. [https://eos.org/wp-content/uploads/2019/02/Feb-19\\_magazine.pdf?x57107](https://eos.org/wp-content/uploads/2019/02/Feb-19_magazine.pdf?x57107)

## 2019 MASTER OF SCIENCE THESES

**Boyer, B.** (Advisor: Luttenton). A comparison of macroinvertebrate drift in a 4th order reach of the Au Sable River, MI.

**Kleindl, P.** (Advisor: Steinman). Impacts of shoreline restoration and source of nutrient enrichment on macrophytes and epiphytic algal communities.

**Knapp, K.** (Advisor: Biddanda). Dynamic carbon cycling in Muskegon Lake – a Great Lakes estuary.

Evans, K., P. Isely, and **A.D. Steinman**. 2019. From lumber to foundries to revitalization: The Muskegon Lake story. In: *Great Lakes revival: How restoring polluted waters leads to rebirth of Great Lakes communities*. Editors: Hartig, J.H., Krantzberg, G., Austin, J.C., and P. McIntyre. Pages 37-46. IAGLR, Ann Arbor, MI. <https://www.researchgate.net/publication/334401156>

Hartmeyer, P., S. Gandulla, **I. Stone\***, **A. Weinke\*\***, and **B. Biddanda**. 2019. Earth landscape as a model for life in extraterrestrial waters. Postcards from the field. November 18, 2019. Eos, American Geophysical Union. <https://americangeophysicalunion.tumblr.com/post/189150901451/earth-landscape-as-a-model-for-life-in>

Murray, M.W., **A.D. Steinman**, J.D. Allan, J.F. Bratton, L.B. Johnson, J.J.H. Ciborowski, and C.A. Stow. 2019. Conceptual frameworks and Great Lakes restoration and protection: A white paper. National Wildlife Federation, Great Lakes Regional Center, Ann Arbor, MI.

**Stone, I.\***, **J. Mancuso\*\***, **K. Knapp\*\***, **A. Weinke\*\***, **R. Ratliff\***, and **B. Biddanda**. 2019. Human civilization: Shaped by the ever-changing earth. A book review of "Origins: How the earth made us" by Lewis Dartnell. 2019. InterChange – Connections for the STEM Classroom, Newsletter of Regional Math and Science Center, GVSU. September 2019. <https://www.gvsu.edu/rmsc/interchange/connections-for-the-stem-classroom-299.htm>

**Weinke, A.\*\***, **B. Biddanda**, R. Green, J. Hoyt, and T. Casserley. April 2019. Exploring microbial ecosystems in Lake Huron. Postcards from the field. Eos, 100(4): 48. [https://eos.org/wp-content/uploads/2019/04/Apr-19\\_magazine.pdf](https://eos.org/wp-content/uploads/2019/04/Apr-19_magazine.pdf)

**Lamar, S.** (Advisor: Partridge). Biological invasions on a large scale: Investigating the spread of baby's breath (*Gypsophila paniculata*) across North America.

**Lane, M.** (Advisor: Rediske). The implementation of qPCR beach monitoring methods: analysis of a multi lab validation study and the role of environmental parameters on a comparison of Colilert and qPCR methods.

**Mock, A.** (Advisor: Ruetz). Evaluating remote site incubators to support restoration of Arctic grayling in Michigan.



**IF YOU WOULD LIKE MORE  
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Rosy Mound Natural Area, Grand Haven, MI