R.B. ANNIS WATER RESOURCES INSTITUTE

2018 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

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2018: DEALING WITH EMERGING THREATS

Dr. Alan Steinman,
The Allen and Helen Hunting Director

The Great Lakes Ecosystem has suffered from over a century of abuse by the hands of humans. The litany of stressors imposed on our lakes, both intentional and unintentional, has been well documented. Indeed, federal programs such as the Great Lakes Legacy Act and the Great Lakes Restoration Initiative have been funded specifically to address these legacy issues.

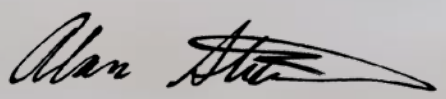
However, new threats continue to emerge and the scientific community needs to remain nimble, creative, collaborative, and transparent in finding solutions. At the Robert B. Annis Water Resources Institute, we are intimately involved in many of these emerging issues.

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

- Dr. Rick Rediske has been at the forefront of the perfluorinated compound (PFAS) contamination of groundwater in the west Michigan region, providing critical information to citizens about the potential toxicity of these compounds and the severity of the situation;
- Dr. Kevin Strychar was invited to join the scientific advisory group that evaluated the potential impacts associated with an oil spill from Line 5 in the Straits of Mackinac;
- Working with Dr. Charlyn Partridge and colleagues at the University of Illinois, my lab is determining the role of microplastics as an adsorptive surface for persistent organic pollutants and the types of organisms that colonize these prolific, non-degrading substrates in our local lakes.
- In addition, I am part of a Great Lakes Early Warning System task force, organized by the International Joint Commission, attempting to develop a system by which we can anticipate or detect stressors that are knocking at the door or are currently here, but not yet an actual threat.

The scientific community is currently in the awkward position of having these "known unknowns"; this may sound like an oxymoron, but in reality we do "know" about some of these emerging threats—but we don't know, at least not yet, a lot about their ecological impacts.

Even more unsettling are the "unknown unknowns", those stressors lurking out there, potentially waiting to emerge. That is why we must remain vigilant in our efforts to continue to preserve, protect, and enhance our precious water resources, the underlying mission of the Annis Water Resources Institute.



Alan Steinman,
The Allen and Helen Hunting Director, AWRI

ARE MICROPLASTICS A THREAT IN MUSKEGON LAKE?

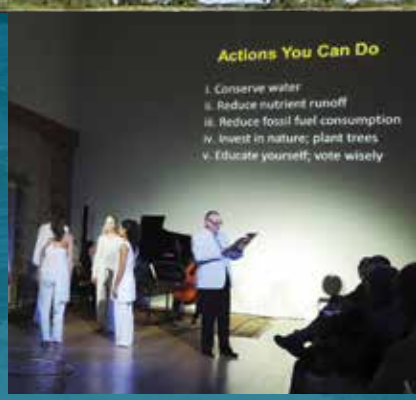
Microplastics are receiving increasing attention as a major pollutant both in the oceans and the Great Lakes. Most research has been devoted to identifying how much and what types of plastics are in our waters, but a large collaborative effort at AWRI is taking a different approach. We are taking known quantities of three different plastics and incubating them in specially designed containers in two locations at two depths in Muskegon Lake. After incubating for either one month or three months, they are retrieved and examined for what types of chemicals and what organisms are attached to the small pieces of plastic. Because microplastics (< 5 mm in size) are easily ingested by larger organisms, there is concern that the chemicals may be toxic to aquatic life after they are consumed. Al Steinman is coordinating the project, with assistance from Charlyn Partridge, Assistant Professor of Water Resources; John Scott, senior analytical chemist at the Illinois Sustainable Technology Center at the University of Illinois; and Maggie Oudsema, a research assistant in the Steinman Lab.

Research assistant Maggie Oudsema and senior analytical chemist John Scott deploy microplastics containers in Muskegon Lake.

RAISING WATER AWARENESS THROUGH DANCE, MUSIC, AND SCIENCE

According to Michigan's Water Strategy, 60% of Michiganders don't know they live in a watershed. Clearly, we need to do better at educating our citizenry about our water resources. To that end, Sookkyung Cho and Hannah Seidel, GVSU Professors of Music and Dance, respectively, teamed with AWRI Director Al Steinman to create a unique performance blending science, music, and dance to tell the story of the Great Lakes. With funding from GVSU's Center for Scholarly and Creative Excellence, the Community Foundation for Muskegon County, and the Hunting Research and Innovation Fund, two performances were held in Muskegon and on the Allendale campus in October.

Professional dancers Courtney Drasner and Kristy Kuhn contemplate polluted water, with pianist Sookkyung Cho (GVSU), violinist Hong-Yi Mo (Detroit Symphony Orchestra), and cellist Jeremy Crosmer (Detroit Symphony Orchestra) playing in the background. Photo Credit: Keely Payne

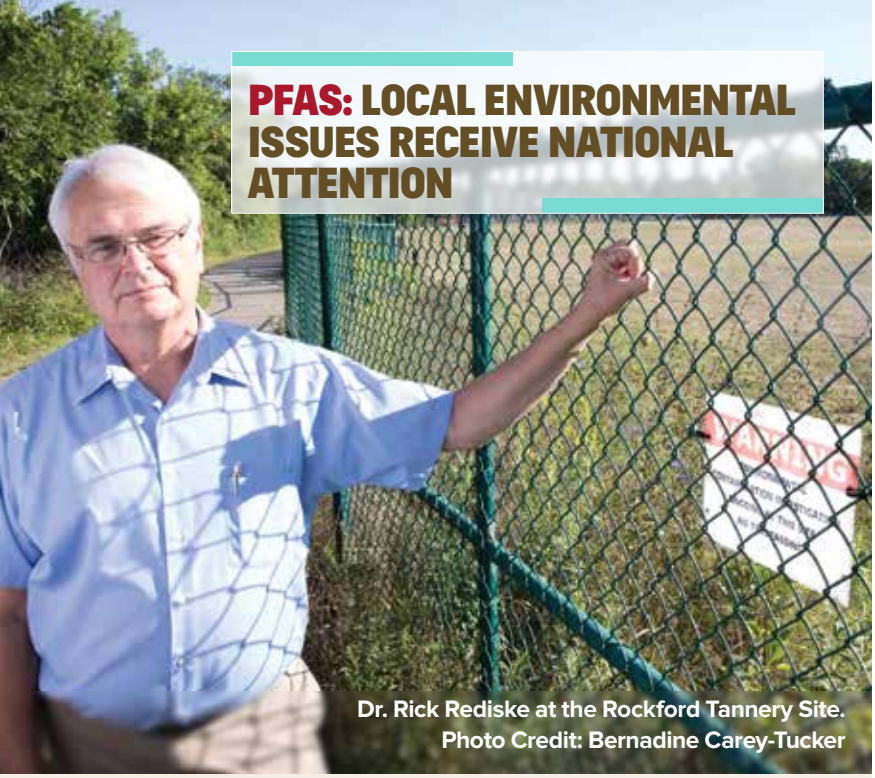


Narrator Roger Ellis (GVSU) reads off actionable items that individuals can take to protect and preserve our water resources, while dancers contemplate our water future. Photo Credit: Keely Payne

AWRI DIRECTOR INVITED TO CHINA

Al Steinman was invited to visit Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences in April to give seminars and work with students on their harmful algal bloom research. Al was the guest of Dr. Liqiang Xie, a former postdoctoral fellow at AWRI. Al visited several lakes along with the cities of Shanghai, Nanjing, Wuxi, and Suzhou.

Al and former visiting Ph.D. student Xiaomei Su standing in front of the Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences.



PFAS: LOCAL ENVIRONMENTAL ISSUES RECEIVE NATIONAL ATTENTION

Dr. Rick Rediske at the Rockford Tannery Site. Photo Credit: Bernadine Carey-Tucker

Per- and polyfluoroalkyl substances (PFAS) are a group of man-made chemicals that have received national attention due to their persistence, mobility, and potential of adverse human and environmental health impacts. These chemicals have been used in commercial products such as Scotchgard™, Teflon™, and Gore-Tex™, in addition to firefighting foams used by the military and fire departments. Dr. Rick Rediske, working with a local citizen group (Concerned Citizens for Responsible Remediation), was one of the first individuals to connect the use of Scotchgard™ at a local tannery with the potential for groundwater contamination in Rockford, MI and in the Rogue River. His work for the citizens' group was featured in a New York Times article and he has provided numerous interviews with local press and TV media. Dr. Rediske is raising public awareness for these chemicals and conducting seminars, public speaking events, webinars, and providing testimony at US EPA and MDEQ sponsored meetings.

AWRI ENTERS THE GENOMICS ERA WITH NEW INSTRUMENT

The Partridge Lab was awarded a National Science Foundation – Major Research Instrumentation (NSF MRI) grant to purchase an Illumina MiSeq Sequencing System. The addition of the Illumina MiSeq will advance the capabilities and resources of the Molecular Ecology Program, ushering it into the era of environmental and ecological genomics. This instrument will help drive innovative and cutting-edge research essential to understanding current key environmental issues, including microplastic pollution, interspecies interactions driving invasive species success, evolution of harmful algal blooms, and the introduction and evolution of viral communities within freshwater systems. Collectively, these projects will provide vital information regarding how some of the most significant environmental challenges of our time are driving changes in the Great Lakes. Furthermore, this work aids our understanding of how habitat degradation drives community level changes within ecosystems, which can be applicable not only for the Great Lakes region but for ecosystems throughout the world.

Ilumina MiSeq instrument image courtesy of Illumina, Inc.®.

NEW STRATEGIES TO ADDRESS THE SAFETY OF RECREATIONAL WATERS

AWRI completed its fourth year of a cooperative agreement with the Michigan Department of Environmental Quality and Public Health Muskegon County to implement rapid qPCR methods for beach monitoring. In 2018, AWRI monitored beaches on 15 inland lakes and 13 Lake Michigan parks for *E. coli* using traditional culture methods and DNA based techniques. AWRI is also in the process of implementing molecular source tracking methods to determine genetic markers related to human, animal, and bird sources.

Graduate student Molly Lane (foreground) and student intern Anna Tarach perform site assessments as part of Great Lakes Beach Monitoring in Muskegon County. Photo Credit: Matt Allen

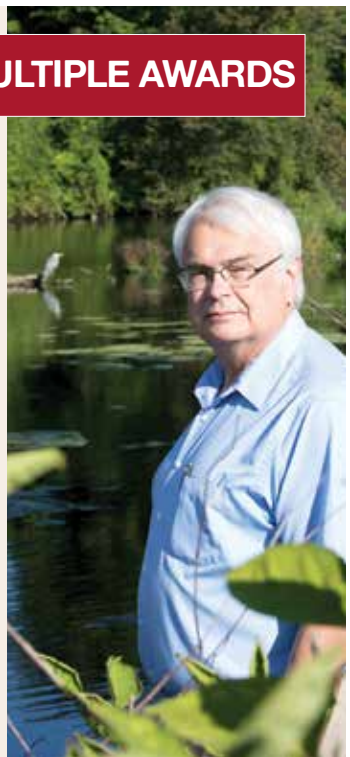
AWRI AND LOCAL STAKEHOLDERS TO ASSESS HEALTH OF LITTLE FLOWER CREEK

Student intern Anna Tarach conducts discharge measurements in Little Flower Creek to determine sediment loading.

AWRI received a grant from the Muskegon Area Environmental Coordinating Council and Freshwater Future to assess and prioritize sources of sediment loading in Little Flower Creek (Muskegon County). Partnering with local stakeholders, AWRI researchers measured suspended and bedload sediment in addition to evaluating sediment contributions from road stream crossings and stream banks. The information will be used to prioritize sites for restoration to reduce sediment loading and restore coldwater fisheries in Little Flower Creek.

DR. RICK REDISKE WINS MULTIPLE AWARDS

Dr. Rick Rediske received the GVSU College of Liberal Arts and Sciences Outstanding Service Award and the C.R. Evenson Award from the West Michigan Environmental Action Council. Both awards recognize Dr. Rediske's recent community service contributions regarding environmental and human health concerns related to PFAS chemicals and his 25 years of service to Great Lakes restoration as part of the Muskegon Lake Watershed Partnership and the White Lake Public Advisory Council.



Dr. Rediske at Rogue River site where PFAS chemicals are entering the river from the discharge of contaminated groundwater.

PROTECTING A FEDERALLY ENDANGERED BUTTERFLY

AWRI intern Alexis Hoskins spent the summer exploring how populations of wild lupine are connected throughout Michigan. This work is important because wild lupine is the only plant the federally endangered Karner blue butterfly feeds on during its larval or caterpillar stage.

AWRI intern Alexis Hoskins sampling populations of wild lupine (*Lupinus perennis*). Photo Credit: Charlyn Partridge

An adult Karner blue butterfly (*Lycaeides melissa samuelis*) feeding on the nectar of the butterfly weed (*Asclepias tuberosa*). Photo Credit: Charlyn Partridge

COLLECTING BABY'S BREATH ACROSS THE WESTERN UNITED STATES

Dr. Charlyn Partridge and graduate student Sarah Lamar spent the summer traveling from Michigan to the state of Washington, collecting tissue from baby's breath (*Gypsophila paniculata*) populations to learn more about the invasion history of this well-known plant. While baby's breath is popular in the floral industry, people are commonly surprised that it can be highly invasive, particularly within Michigan's coastal dunes. It can also invade other relatively harsh environments, such as the sagebrush steppes in the Pacific Northwest. The goal of this work is to understand how baby's breath is able to readily colonize and invade across different ecosystems. The Partridge Lab will also combine genomic data from herbarium samples and gene expression data from these contemporary populations to explore the ways that baby's breath can rapidly adapt to their newly colonized environments. Ultimately, this research may result in shedding light on the mechanisms promoting rapid evolution due to climate change.

Graduate student Sarah Lamar collecting baby's breath samples in Washington. Photo Credit: Charlyn Partridge

UPDATE ON INVASIVE NEW ZEALAND MUD SNAILS

Photo Credit: Mark Luttenton

Since New Zealand mud snails were discovered in the lower portion of the East Branch of the Au Sable River in 2015, Dr. Mark Luttenton and former graduate student Justin Wegner have tracked changes in mud snail numbers every year. New Zealand mud snail numbers have increased from fewer than 100/m^2 to over 30,000/m^2 during this three year period, as the snails continue to spread throughout the Au Sable River watershed.

AWRI WELCOMES DR. SARAH HAMSHER!

Dr. Sarah Hamsher joined GVSU this fall as an assistant professor in a joint position between the Biology Department and AWRI. Sarah is a phycologist (studies algae) and is most interested in diatoms, a group of algae with silica cell walls that are often used as indicators of water quality. She's drawn to questions of speciation and evolutionary relationships, the structure of genomes, and the use of algae as indicators of water quality. In the next year, she'll be investigating the diversity of *Nitzschia*, a diatom genus that often serves an indicator of organic pollution, in local watersheds. Sarah is also interested in studying the role of protists in the environment, water quality in the region, diatom genomics and developing molecular tools to answer biological and ecological questions.

ESTIMATING FISH ABUNDANCE IN STREAMS BY THE MARK-RECAPTURE METHOD

The 2-sample mark-recapture method is a procedure widely used by fishery managers for estimating fish abundance in stream reaches. Fish are sampled from a reach on two consecutive days. Those collected on day 1 are counted, marked, and released; those collected on day 2 are counted again, and the number of recaptured (marked) fish is determined. From these counts, the total number of fish in the reach can be estimated.

This method assumes that no fish enter or exit the study reach between samples—an assumption that may be violated in practice. How much bias (systematic error) in abundance estimates do such violations produce? Previously published answers are inadequate because they address only populations so large that sampling variation is negligible. Dr. Jim McNair (AWRI), Dr. Carl Ruetz (AWRI), Dr. Jiyeon Suh (GVSU), and Ariana Carlson (former GVSU graduate student), therefore developed a new statistical theory for populations of any size and a new practical sampling methodology that reduces dispersal-related bias without requiring additional sampling days.

Sampling fish in a stream reach with a backpack electrofisher.
Photo Credit: Carl Ruetz

RESEARCH SUPPORTS ARCTIC GRAYLING RESTORATION: YEAR 2

Efforts are underway to re-establish Arctic grayling, a species that was extirpated from Michigan by 1936. Alan Mock, a graduate student working with Dr. Carl Ruetz, is assessing streamside egg incubators in Manistee River tributaries to support the reintroduction effort. Alan's research, building on a "pilot" study conducted in 2017, suggests that streamside incubators can work well in Michigan. His research, which will be completed in 2019, is funded by the Little River Band of Ottawa Indians.

Graduate student Alan Mock examines an egg tray from a streamside incubator at Cedar Creek, a tributary of the Manistee River.

AWRI CONDUCTS BIOASSESSMENTS OF FLOWER CREEK

AWRI conducted bioassessments of fish and benthic macroinvertebrate communities in Flower Creek (Oceana and Muskegon Counties) prior to the construction of a swine Confined Animal Feeding Operation (CAFO).

Brook trout collected from Flower Creek.

Adjunct research assistant Travis Ellens and graduate student Kaitlyn Dykstra pull a fyke net from Muskegon Lake to sample the fish assemblage.

Research assistant Maggie Oudsema and graduate student Paige Kleindl (right) collect plankton samples from Muskegon Lake aboard the *W.G. Jackson*.
Photo Credit: Mike Hassett

MUSKEGON LAKE LONG-TERM MONITORING ANNIVERSARY

AWRI has reached a 15-year milestone for the Muskegon Lake long-term monitoring research program. Started in 2003, the program documents changes to Muskegon Lake's ecological health in order to provide data needed to delist Muskegon Lake as a Great Lakes Areas of Concern (AOC). In addition to water quality, chlorophyll, and macroinvertebrate samples, more than 30,000 fish have been sampled around Muskegon Lake's shoreline. Since 2011, the Muskegon Lake Observatory Buoy has captured weather and water quality data as high-resolution time-series data that are freely available at www.gvsu.edu/buoy. An annual water quality dashboard of Muskegon Lake is available at www.gvsu.edu/wri/director/dashboard.

Technical call-in Anthony Weinke (left) and Dr. Bopi Biddanda (right) work on deploying the GVSU Observatory in April 2018.

RIVERSIDE PARK FISH & AQUATIC INVERTEBRATE MONITORING

Ottawa County Parks is initiating a project at Riverside Park to enhance the hydrologic connection of Kirby Bayou to the Grand River. AWRI staff in the Ruetz Lab measured water quality and sampled fish and aquatic invertebrates to catalog pre-restoration conditions in the bayou. Once the habitat restoration is completed, AWRI staff will re-sample the bayou to assess ecosystem change. This restoration is expected to improve the ecological health of Kirby Bayou.

Technical call-in Maria Scarborough holds a common carp captured in Kirby Bayou.

FARE THEE WELL, JOHN KOCHES

On April 30, 2018, after nearly 30 years of service at AWRI-GVSU, John Koches retired. John's entire career was spent working to provide critical thinking tools to decision makers with the ability to impact our region's natural resources. A worthwhile endeavor.

We thank him for his years of service, the training he provided to countless students and staff, and his unfailing commitment to AWRI and GVSU.

WHERE ARE THEY NOW?

KIM OLDENBORG

Kim Oldenborg received her Master's degree working in the Steinman Lab; her thesis examined the impacts of sediment dredging on sediment phosphorus flux in a restored riparian wetland. Kim published her research in the journal *Science of the Total Environment* and received the Graduate Dean's Citation for Academic Excellence for Outstanding Publication the Fall 2018 semester. She is now employed as the Northeast Lakeshore Total Maximum Daily Load Project Coordinator for the Wisconsin Department of Natural Resources in Madison, WI.

Graduate student Kim Oldenborg traveling to a restored Bear Lake wetland to collect sediment core samples for her graduate project.
Photo Credit: Mike Hassett

KRISTIN THOMAS

Kristin (Nelson) Thomas, a native of Minnesota, earned a M.S. in Biology at AWRI in 2008. Her thesis research focused on the distribution of zebra mussels in Great Lakes coastal wetlands. Since graduating, Kristin has worked as an aquatic ecologist for Michigan Trout Unlimited, focusing on coldwater stream conservation. When Kristin reflects on her time at AWRI, she says "the project management skills I learned during graduate school have been an incredible asset to my career."

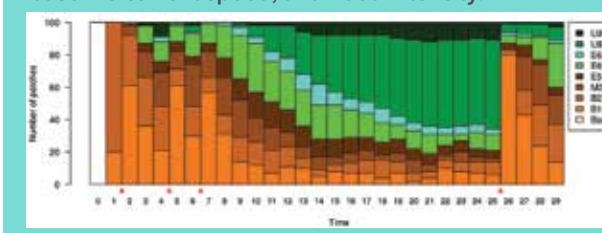
Kristin installs wood structures as part of a habitat restoration project in Rice Creek (Calhoun County).

DR. IGOR MRDJEN JOINS AWRI ENVIRONMENTAL CHEMISTRY LAB

Dr. Igor Mrdjen, Ph.D., Ohio State School of Public Health, joined AWRI as a postdoctoral research associate in September 2018. His doctoral research focused on the causes, consequences, and solutions to harmful algal blooms in small lakes and ponds and part of his work recently was published in Environmental Science and Technology. Igor will be joining Dr. Rick Rediske's lab and work on projects dealing with qPCR and microbial source tracking of fecal bacteria in the environment, cyanobacteria blooms in drowned river mouth lakes, and emerging chemical contaminants in the Great Lakes basin.

COMPUTER MODELING THE ECOLOGICAL SUCCESSION OF ALGAL COMMUNITIES

Algal communities growing on the beds of rocky-bottom streams pass through a predictable sequence of stages with different species compositions. This process is called succession. But succession is punctuated by patchy invertebrate grazing of algae and by scouring during floods. Dr. Jim McNair (AWRI), Dr. Dean DeNicola (Slippery Rock Univ., PA), and Dr. Jiyeon Suh (GVSU) are developing a simulation model that predicts the combined effects of succession, grazing, and floods on algal communities and how they are modulated by light level, nutrient level, baseline current speed, and flood intensity.



An example of model output, showing the development of algal communities in 100 different patches. Codes and colors for the different community types are listed in the upper right corner. Red triangles along the time axis indicate flood events.

AWRI AT WORK

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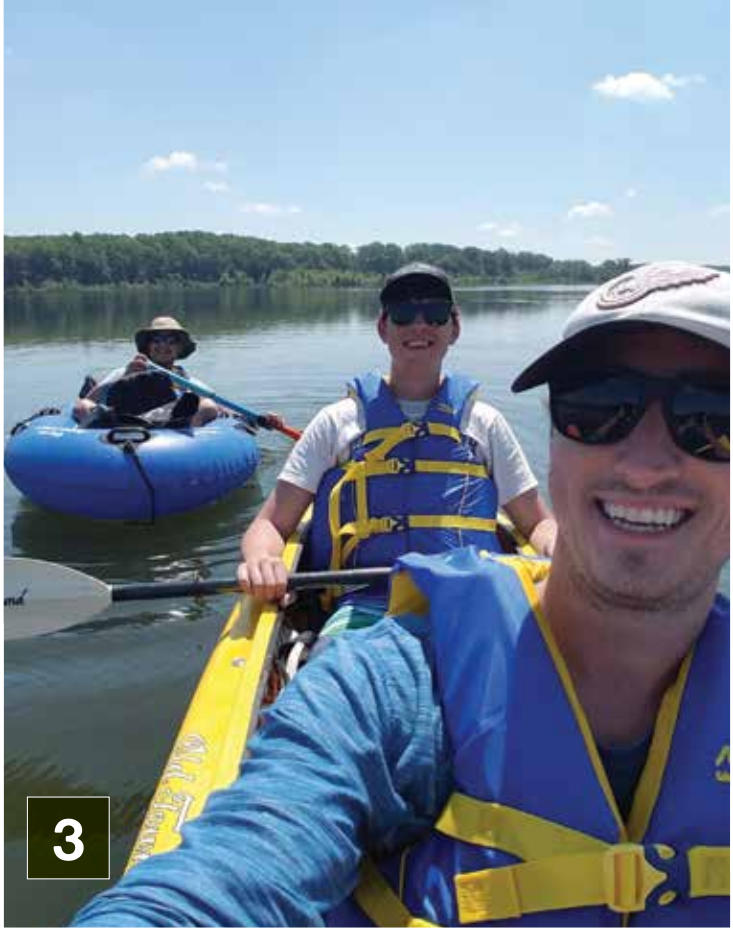

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1 Research assistant Maggie Oudsema cores through ice to collect a water sample.

2 Dr. Rick Rediske (left) and adjunct research assistant Travis Ellens (right) surveying fish in Flower Creek.

3 Dr. Bopi Biddanda (left), technical call-in Anthony Weinke (center), and intern Riley Duff (right) paddling to a field site.

4 Graduate student Matt Allen sampling bedload at Lake Michigan.

5 Graduate student Paige Kleindl measures stream flow in the Spring Lake watershed.

6 Technical call-in Maria Scarborough (left), intern Bert Carey (center), and graduate student Alan Mock (right) sorting aquatic macroinvertebrates.

7 GVSU P. Douglas Kindschi Undergraduate Research Fellow Rachel Orzechowski kayaking through the lower Muskegon River wetland restoration area.

8 Science instructors Tom Jackson (right) and Ann Hesselsweet (far right) lead a class onboard the *W.G. Jackson*.

9 Dr. Charlyn Partridge (far left), graduate students Sarah Lamar (left), Hailee Leimbach-Maus (back), and Emma Rice (right), and intern Alexis Hoskins (front) at Sleeping Bear Dunes.

10 Graduate student Jason Lorenz with a lake sturgeon.


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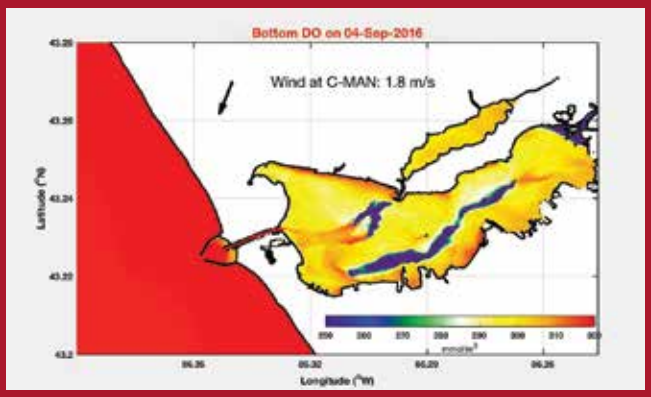
HYDROLOGIC INTRUSIONS AND HYPOXIA DYNAMICS: **NEW INSIGHTS**

Using available time-series physical measurements, the Biddanda Lab and postdoctoral associate, Dr. Qianqian Liu developed a working 3-D hydrodynamic model for Muskegon Lake. The model found substantial intrusions taking place from Lake Michigan into the bottom of Muskegon Lake during the summer-fall period when NW winds cause nearshore coastal upwelling along Michigan's coast. Such episodic intrusions of cold and oxygenated nearshore water into Muskegon Lake (each amounting to as much as 10% of lake volume) have the potential to reduce the intensity of hypoxia in bottom waters, improving fish habitat.

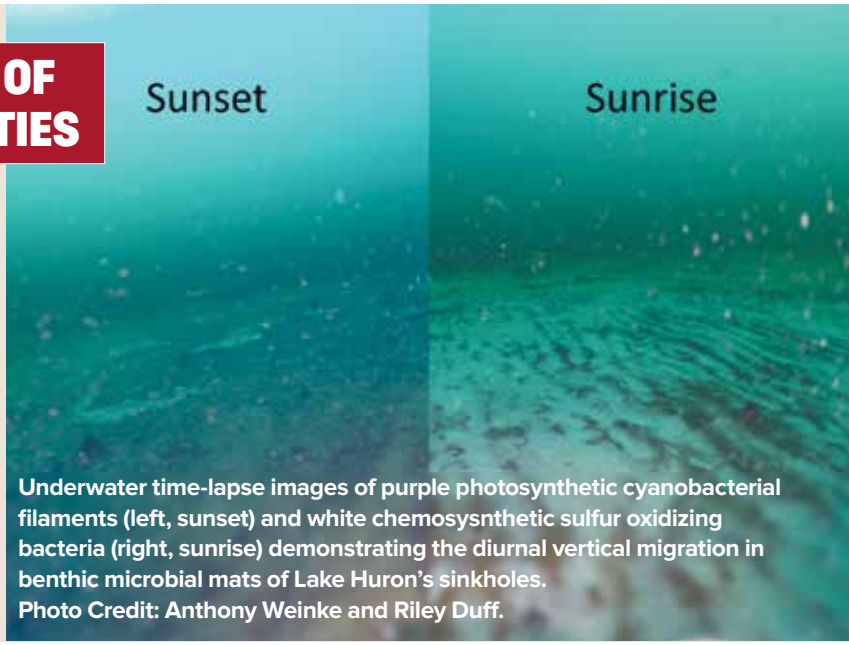


Hydrodynamic model simulation of cold and oxygenated nearshore water intrusion (blue color) into Muskegon Lake as of September 4, 2016 by postdoctoral associate, Dr. Qianqian Liu. Arrow points to wind direction.

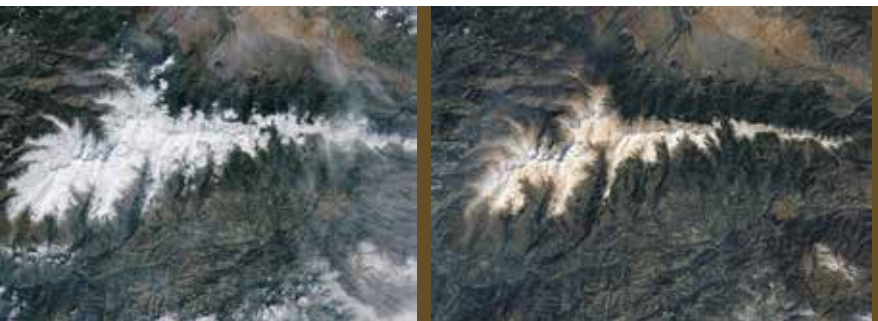
Dr. Biddanda heading out to the Muskegon Lake channel to check on temperature and dissolved oxygen sensors placed in the channel bed that make direct measurements of Lake Michigan water intrusions. Photo Credit: Anthony Weinke.

DIEL VERTICAL MIGRATION OF MICROBIAL MAT COMMUNITIES

Low-oxygen, high-sulfur submerged sinkholes in Lake Huron are characterized by microbial mats that resemble life on early Earth. Now for the very first time, the Biddanda Lab and their research collaborators have glimpsed the dramatic day-night shift between photosynthetic cyanobacteria and chemosynthetic sulfur oxidizing bacteria through time-lapse photography. The capacity for diurnal vertical migration to optimize the capture of varying light and sulfur levels in these modern-day communities may explain how such mobile and versatile communities could have played a role in oxygenating the early Earth.



Underwater time-lapse images of purple photosynthetic cyanobacterial filaments (left, sunset) and white chemosysnthetic sulfur oxidizing bacteria (right, sunrise) demonstrating the diurnal vertical migration in benthic microbial mats of Lake Huron's sinkholes. Photo Credit: Anthony Weinke and Riley Duff.



The Sierra Nevada mountains in Spain containing numerous glacial lakes before (left) and after (right) a major dust deposition event in late February 2017. Photo Credit: NASA.

THE ROLE OF TERRESTRIAL DUST IN AQUATIC ECOSYSTEMS

According to visiting scholar Prof. Manuel Villar-Argaiz, NASA satellite data indicate that airborne dust has increased worldwide over the last four decades accelerated by climate change. Dust arising from the subtropical arid regions of the world's continents can fertilize far-flung ecosystems across the globe with nutrients such as iron and phosphorus - impacting sensitive nutrient-depleted lakes and oceans.

A LAKE MICHIGAN EXPERIENCE IN CHICAGO

The *W.G. Jackson* traveled to 31st Street Harbor in Chicago for outreach cruises with the Shedd Aquarium. AWRI science instructors were able to work closely with Shedd Aquarium educators during the five days of their visit. A highlight of the Shedd's *Lake Michigan Experience* included the use of a remotely operated vehicle (ROV) to view fish in Lake Michigan. Shannon Fuller from Shedd notes, "Thank you for the fantastic programming your team provided alongside Shedd staff."

Shedd staff conferring with AWRI marine engineer, Dave Fisher (third from right).

A BANNER YEAR FOR EDUCATOR PROFESSIONAL DEVELOPMENT COLLABORATIONS

Great Lakes Literacy Workshop at AWRI.

AWRI's K-12 professional development workshops usually involve one or maybe two organizations. However, AWRI broadened its partnerships this year. Cranbrook Institute of Science's Freshwater Forum had funding for workshops, so AWRI inquired if the Forum would support a Project WET workshop to be offered along with the other educational workshops that were hosted by the Muskegon Nature Preserve. The answer was yes! So in June, teachers from throughout the state gathered at AWRI for Project WET. Facilitators from the Lower Grand River Organization of Watersheds, Cornerstone University, and Muskegon Nature Preserve assisted in leading activities. AWRI again collaborated with the Freshwater Forum for a second workshop on Great Lakes Literacy. Presenters included AWRI, the Forum, and West Michigan Environmental Action Council. Additionally, AWRI partnered with the West Michigan Regional Shoreline Development Commission for an air quality workshop and the GVSU Geology Department for a GLOBE workshop.

Another collaboration was with the Raven Hill Discovery Center in East Jordan for a workshop in conjunction with the Smithsonian Institute's Water/Ways exhibit (top). AWRI Water/Ways events were also held at the Artworks in Big Rapids (bottom).

A BLAST FROM THE PAST – EMERGING DISEASES

Increased international trade, global warming opening up new trade routes, and increased shipping are allowing quicker globalization of invasive species worldwide. This past year, the Strychar Lab studied whether invasive dreissenid mussels from Eurasia were harboring novel emerging pathogens, specifically viruses. Preliminary work suggests such viruses exist deep in the Great Lakes sediments and are not necessarily from invasive species, but are emerging after having been buried for tens to hundreds or thousands of years.

Dreissenid mussels attached to a Muskegon Lake buoy. Photo Credit: Mike Hassett

JAPANESE DELEGATION VISITS AWRI

At the request of the Michigan Governor's Office, AWRI hosted a delegation from the Shiga Prefecture in Japan in September. Lake Biwa, Japan's largest freshwater lake, is located in this prefecture and the delegates were curious to learn about our restoration activities on Muskegon Lake and the Great Lakes. Al Steinman provided them with an overview of our activities while Shirley McIntire, science instructor, led them through various analyses onboard the *W.G. Jackson*. The delegation was accompanied by Jon Allan, Director of the Michigan Office of the Great Lakes.

Al Steinman with the Japanese delegation onboard the *W.G. Jackson* cruising Muskegon Lake.

IS FOOD PRODUCTION SAFER WITH NEW *E. coli* TESTING?

Funded by the Michigan Department of Agriculture and Rural Development, new methods are being developed and tested to determine if imaging flow cytometry can be used to identify food contamination in seconds to minutes versus traditional techniques requiring minutes, hours, or days. Such testing has the benefit of making agricultural food production safer, healthier, and more profitable for farmers by reducing the amount of rejected produce.

GVSU undergraduate intern Darrick Gates developing faster methods to study *Escherichia coli* (*E. coli*) in food contamination using state-of-the art imaging flow cytometry. Photo Credit: Nate Hoekstra

THE BILLION DOLLAR GREAT LAKES QUESTION

Could the Great Lakes survive an oil spill like the Deepwater Horizon? Aquatic ecosystems are annually threatened by oil pollution. This is most evident in marine ecosystems where thousands to millions of gallons of oil are accidentally released (e.g. Deepwater Horizon) and then compounded with chemicals used to clean-up the spill. In the Great Lakes, much less is known about possible impacts of an oil spill, but it is increasingly becoming an emerging problem caused by aging infrastructure (e.g. Enbridge Line 5 pipeline), oil leaks, and/or increased oil exploration. Unlike marine ecosystems, freshwater researchers have little knowledge of the effects of oil spills on: (1) the benthos, (2) microbiota (e.g. bacteria), (3) whether "oil-eating" bacteria exist, (4) effects during winter (e.g. under the ice), and (5) clean-up and restoration. This lack of knowledge has the potential to be devastating in the Great Lakes. In an "Independent Risk Analysis for the Straits Pipelines" available at: https://mipetroleumpipelines.com/document/independent-risk-analysis-straits-pipelines-final-report, the Strychar Lab participated in a report analyzing the emerging short- and long-term ecological impacts of a potential spill.

CRUISING WITH THE COMMUNITY FOUNDATION FOR MUSKEGON COUNTY STAFF

The Community Foundation for Muskegon County has been a critical partner with AWRI, ever since we moved to Muskegon from Allendale in 2001. Their continued support of our operations has been instrumental in our success. We showed our appreciation by hosting a sunset cruise in June on the *W.G. Jackson*, which included a summary of AWRI's research activities on Muskegon Lake and Lake Michigan by Al Steinman. A splendid time was had by all.

AWRI FACULTY & STAFF

THE ALLEN AND HELEN HUNTING DIRECTOR:

Alan Steinman, Professor

STAFF/ADMINISTRATIVE:

Tonya Brown, AWRI Assistant
Chelsea Hartman, Student Clerical Assistant
Roxana Taylor, Secretary
Paula Wicklund, Office Coordinator

FACILITIES/MAINTENANCE:

Len Wittlieff, Maintenance

INFORMATION SERVICES CENTER:

John Koches, Associate Research Scientist
(retired: June 2018)

OUTREACH & EDUCATION:

Janet Vail, Research Scientist
- Paula Capizzi, Lead Instructor DJA
- Sherry Claflin, Science Instructor
- Jamie Cross, Science Instructor
- Cheri Gerhart, Science Instructor
- Ann Hesselsweet, Science Instructor
- Tom Jackson, Science Instructor
- Shirley McIntire, Science Instructor
- Maggie Pennell, Science Instructor
- Penny Reid, Science Instructor
- Michele Smith, Science Instructor
- Diane Veneklasen, Science Instructor

GVSU VESSELS/FIELD STATION OPERATIONS:

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

ECOLOGICAL RESEARCH, ENVIRONMENTAL CHEMISTRY:

Richard Rediske, Professor
- Igor Mrdjen, Postdoctoral Researcher
- Brian Scull, Research Assistant

ECOLOGICAL RESEARCH, ENVIRONMENTAL BIOLOGY:

Bopaiah Biddanda, Professor
- Riley Duff, Technical Call-in
- Scott Kendall, Technical Call-in
- Qianqian Liu, Postdoctoral Researcher
- 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
- Branden Wilson, Technical Call-in

Carl Ruetz III, Professor
- Travis Ellens, Adjunct Research Assistant
- Maria Scarborough, Technical Call-in

Alan Steinman, Professor
- Aaron Dunnuck, Adjunct Research Assistant
- Nicole Hahn, Technical Call-in
- Mike Hassett, Scientific Technician
- Lidiia Iavorivska, Postdoctoral Researcher
- Emily Kindervater, Adjunct Research Assistant
- Rachel Orzechowski, Undergraduate Student Assistant
- Maggie Oudsema, Research Assistant
- Kurt Thompson, Research Associate

Kevin Strychar, Professor

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Dr. Carol Johnston, South Dakota State University
Dr. Gary Lamberti, University of Notre Dame
Dr. Don Scavia, University of Michigan, Chair

GRADUATE STUDENTS:

Biddanda, major advisor
- Katie Knapp, AWRI Assistantship
- Jasmine Mancuso, AWRI Assistantship

Luttenton, major advisor
- Barney Boyer, AWRI Assistantship

McNair, major advisor
- Emma Rice, AWRI Assistantship
- Jay Zuidema, AWRI Assistantship

Partridge, major advisor
- Ben Giffin
- Sarah Lamar, AWRI Assistantship
- Hailee (Pavisich) Leimbach-Maus, AWRI Assistantship
- Andrew Pyman, AWRI Assistantship

Rediske, major advisor
- Matthew Allen, AWRI Assistantship
- Molly Lane, AWRI Assistantship
- Daniel Myers, AWRI Assistantship

Ruetz, major advisor
- Travis Ellens
- Kaitlyn (Emelander) Dykstra, AWRI Assistantship
- Jason Lorenz
- Alan Mock, AWRI Assistantship
- Maggie Oudsema

Steinman, major advisor
- Paige Kleindl, AWRI Assistantship
- Kimberly Oldenborg, AWRI Assistantship

Strychar, major advisor
- Eve Choi
- Cassidy Gilmore, AWRI Assistantship
- Tyler Harman, AWRI Assistantship
- Jennifer Kovacs

INTERNSHIPS & SCHOLARSHIPS:

AWRI provides opportunities for students to pursue their interests in our environment. The following students received internships during 2018.

HERBERT VANDERMEY INTERN:
- Matthew Allen

ROBERT B. ANNIS FOUNDATION INTERNS:
- Bert Carey
- Anna Tarach
- Kailey Keenan-Whittemore

AWRI INTERNS:
- Darrick Gates
- Alexis Hoskins

BILL AND DIANA WIPPERFURTH SCHOLARSHIP:
- Darrick Gates

RON WARD SCHOLARSHIP
- Shelby Byrne
- Sarah Collier
- Abigail Crouch
- Natalie Graber
- Jocie Madsen
- Eric Roberts

PEER-REVIEWED PUBLICATIONS

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

Biddanda, B.A., A.D. Weinke, S.T. Kendall, L.C. Gereaux**, T.M. Holcomb*, M.J. Snider**, D.K. Dila**, S.A. Long, C. VandenBerg*, K. Knapp**, D.J. Koopmans***, K. Thompson, J.H. Vail, M.E. Ogdahl, Q. Liu***,** T.H. Johengen, E.J. Anderson, and S.A. Ruberg. 2018. Chronicles of hypoxia: Time-series buoy observations reveal annually recurring seasonal basin-wide hypoxia in Muskegon Lake – a Great Lakes estuary. Journal of Great Lakes Research, 44: 219-229. doi: 10.1016/j.jglr.2017.12.008

Cao, Q., **A.D. Steinman**, X. Wan, and L. Xie. 2018. Combined toxicity of microcystin-LR and copper on lettuce (*Lactuca sativa* L.). Chemosphere, 206: 474-482. doi: 10.1016/j.chemosphere.2018.05.051

Cao, Q., **A.D. Steinman**, X. Wan, and L. Xie. 2018. Bioaccumulation of microcystin congeners in soil-plant system and human health risk assessment: A field study from Lake Taihu region of China. Environmental Pollution, 240: 44-50. doi: 10.1016/j.envpol.2018.04.067

Cao, Q., **A.D. Steinman**, L. Yao, and L. Xie. 2018. Effects of light, microorganisms, farming chemicals and water content on the degradation of microcystin-LR in agricultural soils. Ecotoxicology and Environmental Safety, 156: 141-147. doi: 10.1016/j.ecoenv.2018.03.030

Cao, Q., **A.D. Steinman,** L. Yao, and L. Xie. 2017. Toxicological and biochemical responses of the earthworm *Eisenia fetida* to cyanobacterial toxins. Scientific Reports, 7(1). doi: 10.1038/s41598-017-16267-8

Chiang, E., M. Schmidt, M. Berry, **B.A. Biddanda**, A. Burtner, T. Johengen, D. Palladino, and V. Denef. 2018. Verrucomicrobia are prevalent in north-temperate freshwater lakes and display class-level preferences between lake habitats. PLoS ONE, 13(3): e0195112. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0195112

Cooper, M.J., G.A. Lamberti, A.H. Moerke, **C.R. Ruetz III**, D.A. Wilcox, V.J. Brady, T.N. Brown, J.J.H. Ciborowski, J.P. Gathman, G.P. Grabas, L.B. Johnson, and D.G. Uzarski. 2018. An expanded fish-based index of biotic integrity for Great Lakes coastal wetlands. Environmental Monitoring and Assessment, 190: 580. doi: 10.1007/s10661-018-6950-6

Gerig, B.S., D.T. Chaloner, D.J. Janetski, A.H. Moerke, **R.R. Rediske**, **J.P. O'Keefe**, D.A. de Alwis Pitts, and G.A. Lamberti. 2018. Environmental context and contaminant biotransport by Pacific salmon interact to mediate the bioaccumulation of contaminants by stream-resident fish. Journal of Applied Ecology, 55: 1846-1859. doi: 10.1111/1365-2664.13123

Haslun, J.A.***, B. Hauff Salas*****, K.B. Strychar**, N.E. Ostrom, and J.M. Cervino. 2018. Biotic stress contributes to seawater temperature induced stress in a site-specific manner for *Porites astreoides*. Marine Biology, 165:160.

Isely, P., E. Sterrett Isely, C. Hause, and **A.D. Steinman**. 2018. A socioeconomic analysis of habitat restoration in the Muskegon Lake area of concern. Journal of Great Lakes Research, 44: 330-339. doi: 10.1016/j.jglr.2017.12.002

Kraff, D. and **A.D. Steinman**. 2018. Integrated watershed management in Michigan: challenges and proposed solutions. Journal of Great Lakes Research, 44: 197-207. doi: 10.1016/j.jglr.2017.10.007

NON-PEER REVIEWED PUBLICATIONS

Biddanda, B. A. 2018. Postcards from the Field: In the estuaries of the Great Lakes, a researcher holds up mooring cables encrusted with mussels and bryozoans. Eos, 99(7). July 2018.

Biddanda, B.A., A. Weinke**, and **K. Knapp****. 2018. Chronicles of hypoxia: GVSU's time-series observatory tracks hypoxia and ecosystem changes in a Great Lakes estuary – Muskegon Lake Area of Concern. InterChange – Connections for the STEM Classroom, Newsletter of Regional Math and Science Center, GVSU. February 2018. http://www.gvsu.edu/rmsc/interchange/connections-for-the-stem-classroom-299.htm

Biddanda, B.A., A. Weinke**, **R. Ratliff, K. Knapp****, M. Villar-Argaiz, P. Carrillo, and J. Medina-Sanchez. 2018. A Grander view of life: From backyard observations to the theory of our origins. A book review of "Darwin's backyard: How small experiments led to a big theory" by James Costa. (2017). InterChange – Connections for the STEM Classroom, Newsletter of Regional Math and Science Center, GVSU. April 2018. https://www.gvsu.edu/rmsc/interchange/2018-april-connections-1351.htm

Ide, C., M. Fisher, D. Flaspohler, R. Powell, **K. Strychar**, and J. Olin. 2018. Task E: Analyzing the short- and long-term ecological impacts. In: Independent Risk Analysis for the Straits Pipelines – Final Report, September 15, 2018. Project ID 1801011. https://mipetroleumpipelines.com/document/independent-risk-analysis-straits-pipelines-final-report

Liu, B., C.E. McClean, D.T. Long, **A.D. Steinman**, and R.J. Stevenson. 2018. Eutrophication and recovery of a lake inferred from sedimentary diatoms originating from different habitats. Science of the Total Environment, 628-629: 1352-1361. doi: 10.1016/j.scitotenv.2018.02.174

Liu, Q.***, E.J. Anderson, Y. Zhang, **A.D. Weinke**, **K.L. Knapp**** and **B.A. Biddanda**. 2018. Modeling reveals the role of coastal upwelling and hydrologic inputs on biologically distinct water exchanges in a Great Lakes estuary. Estuarine, Coastal and Shelf Science, 209: 41-55. doi:10.1016/j.ecss.2018.05.014

Loggie, J.W., S.R. Garner, **C.G. Partridge**, B. Dixon, R. Knapp, and B.D. Neff. 2018. A test of the effect of androgens on immunity: No relationship between 11-ketotestosterone and immune performance in bluegill (*Lepomis macrochirus)*. General and Comparative Endocrinology, 261: 1-8. doi: 10.1016/j.ygcen.2018.01.016

McNair, J., C.R. Ruetz III, A. Carlson, and J. Suh. 2018. Reducing effects of dispersal on the bias of 2-sample mark-recapture estimators of stream fish abundance. PLoS ONE, 13(8): e0200733 doi: 10.1371/journal.pone.0200733

Oldenborg, K.** and **A.D. Steinman**. 2019. Impact of sediment dredging on sediment phosphorus flux in a restored riparian wetland. Science of the Total Environment, 650: 1969-1979.

Salk, K.R., **A.D. Steinman,** and N.E. Ostrom. 2018. Wetland restoration and hydrological reconnection result in enhanced watershed nitrogen retention and removal. Wetlands, 38: 349-359. doi: 10.1007/s13157-017-0972-7

Schmidt, M., **B. Biddanda, A. Weinke**,** E. Chiang, **F. Januska***, R. Props, and V. Denef. In Press. Microhabitats shape diversity-productivity relationships in freshwater bacterial communities. Ecology.

Steinman, A.D. In Press. Response to Osgood Comment: Alum efficiency 11 years following treatment: Phosphorus and macroinvertebrates. Lake and Reservoir Management.

Steinman, A.D., M. Hassett, and **M. Oudsema**. 2018. Effectiveness of Best Management Practices to reduce phosphorus loading to a highly eutrophic lake. International Journal of Environmental Research and Public Health, 15(10), 2111. doi: 10.3390/ijerph15102111

Steinman, A.D., M.C. Hassett, M. Oudsema, and **R. Rediske**. 2018. Alum efficacy 11 years following treatment: phosphorus and macroinvertebrates. Lake and Reservoir Management, 34: 167-181. doi: 10.1080/10402381.2017.1402834

Strychar K.B. and P.W. Sammarco. In Press. An overview with discussions on freshwater and marine ecosystems in North America. In: Climate Change and Non-infectious Fish Disorders (CCNFD). Eds: P.T.K Woo and G.K. Iwama. CAB International (www.cabi.org), Wallingford, Oxfordshire, UK.

Su, X., **A.D. Steinman**, Q. Xue, Y. Zhao, and L. Xie. 2018. Evaluating the contamination of microcystins in Lake Taihu, China: The application of equivalent total MC-LR concentration. Ecological Indicators, 89: 445-454. doi: 10.1016/j.ecolind.2017.11.042

Thum, R.A., **S.R. Parks**, **J.N. McNair**, P. Tyning, P. Hausler, L. Chadderton, A. Tucker, and A. Monfils. 2017. Survival and vegetative regrowth of Eurasian and hybrid watermilfoil following operational treatment with auxinic herbicides in Gun Lake, Michigan. Journal of Aquatic Plant Management, 55: 103-107.

Weinke, A.D.** and **B.A. Biddanda**. 2018. From bacteria to fish: Ecological consequences of seasonal hypoxia in a Great Lakes estuary. Ecosystems, 21: 426-442. doi: 10.1007/s10021-017-0160-x

Xue, Q., **R.R. Rediske**, Z. Gong, X. Su, H. Xu, Y. Cai, Y. Zhao, and L. Xie. 2018. Spatio-temporal variation of microcystins and its relationship to biotic and abiotic factors in Hongze Lake, China. Journal of Great Lakes Research, 44: 253-262. doi: 10.1016/j.jglr.2017.12.004

Knapp, K., R. Ratliff*, A. Weinke**, Q. Liu***, T. Claffey and **B. Biddanda**. 2017. Shaping our future: an astrobiologist's long view of life on Earth and beyond. A book review of "Earth in human hands: shaping our planet's future" by David Grinspoon. InterChange – Connections for the STEM Classroom, Newsletter of Regional Math and Science Center, GVSU. November 2017. http://www.gvsu.edu/rmsc/interchange/connections-for-the-stem-classroom-299.htm

Medina-Sanchez, J., M. Villar-Argaiz, G. Herrera, P. Carrillo and **B.A. Biddanda.** 2018. Postcards from the Field: A view from Spain's Lagunas de Ruidera, a site facing multiple human-induced stressors. Eos, 99(10). October 2018. https://eos.org/wp-content/uploads/2018/09/Oct-18_magazine.pdf

The Muskegon Lake Buoy was featured in an article in the publication Environmental Monitor: Gillies, Jeff. 2018. Data buoy powers Muskegon Lake hypoxia research. Environmental Monitor, August 2018, pages 28-29. https://fondriest.com/pdf/2018_em_summer_high.pdf

2018 MASTER OF SCIENCE THESES

Dykstra (Emelander), K. (Advisor: Ruetz). Occupancy and detection of yellow perch in Great Lakes coastal wetlands.

Leimbach-Maus (Pavisich), H. (Advisor: Partridge). Genetic structure of invasive baby's breath populations in a Michigan dune system.

Myers, D. (Advisor: Rediske). Investigating erosion and ecological impacts to an urban coldwater stream using multiple techniques.

Oldenborg, K. (Advisor: Steinman). Impact of sediment dredging on phosphorus flux in a restored wetland.

Rice, E. (Advisor: McNair). Assessment of invasive baby's breath control methods in the northwest Michigan dunes.

Zuidema, J. (Advisor: McNair). Estimating components of stream metabolism using the free water dissolved oxygen method.

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

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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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