R.B. Annis Water Resources Institute

2020
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

Table of Contents

2020: Embrace Change

Dr. Alan Steinman,
The Allen and Helen Hunting Director

This column contains two promises. First, there will be no whining about COVID. Yes, it's real, it's here, and it sucks. Enough. Please be safe, be smart, be healthy.

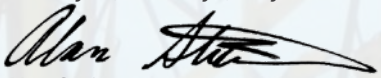
Instead, let me focus on change, as 2020 has certainly been a year characterized by change, both globally and regionally. We know change is constant. Ignoring that principle and not adapting runs the risk of stagnation or even worse, extinction. I am sure the dinosaurs, Blockbuster, or Polaroid would agree, if they only could.

How do we make sure that we, at the Robert B. Annis Water Resources Institute (AWRI), are prepared to deal with the dynamic challenges facing our water resources? First, we must be strategic. This involves having people who have the intellectual capacity and willingness to shift gears when necessary. We are all trained in areas of specialization, but this should not, indeed cannot, pigeonhole us into narrow research topics. For example, by being open-minded, collaborative, and nimble, our molecular ecologist, Dr. Charlyn Partridge, has migrated from working on the genetic basis of fish behavior to (1) the population genetics of the invasive plant baby's breath, (2) the genetic composition of bacteria colonizing microplastics, (3) the population genetics of the invasive insect hemlock woolly adelgid, and (4) now testing for COVID. Additionally, the research focus of our environmental chemist, Dr. Rick Rediske, has changed over a 30-year career at AWRI from working on PCB contamination, to toxins released from harmful algal blooms, to PFAS, and finally COVID testing with Dr. Partridge.

Changing research topics is not a trivial undertaking—no matter how strategic we may be, adapting to changing conditions also requires learning new techniques, working with new instrumentation and technology, and understanding a whole new system. In short, we must have highly developed and refined critical thinking skills. As the famed French microbiologist, Louis Pasteur, once said: chance favors only the prepared mind. (Of course, he said it in French, with far more panache.)

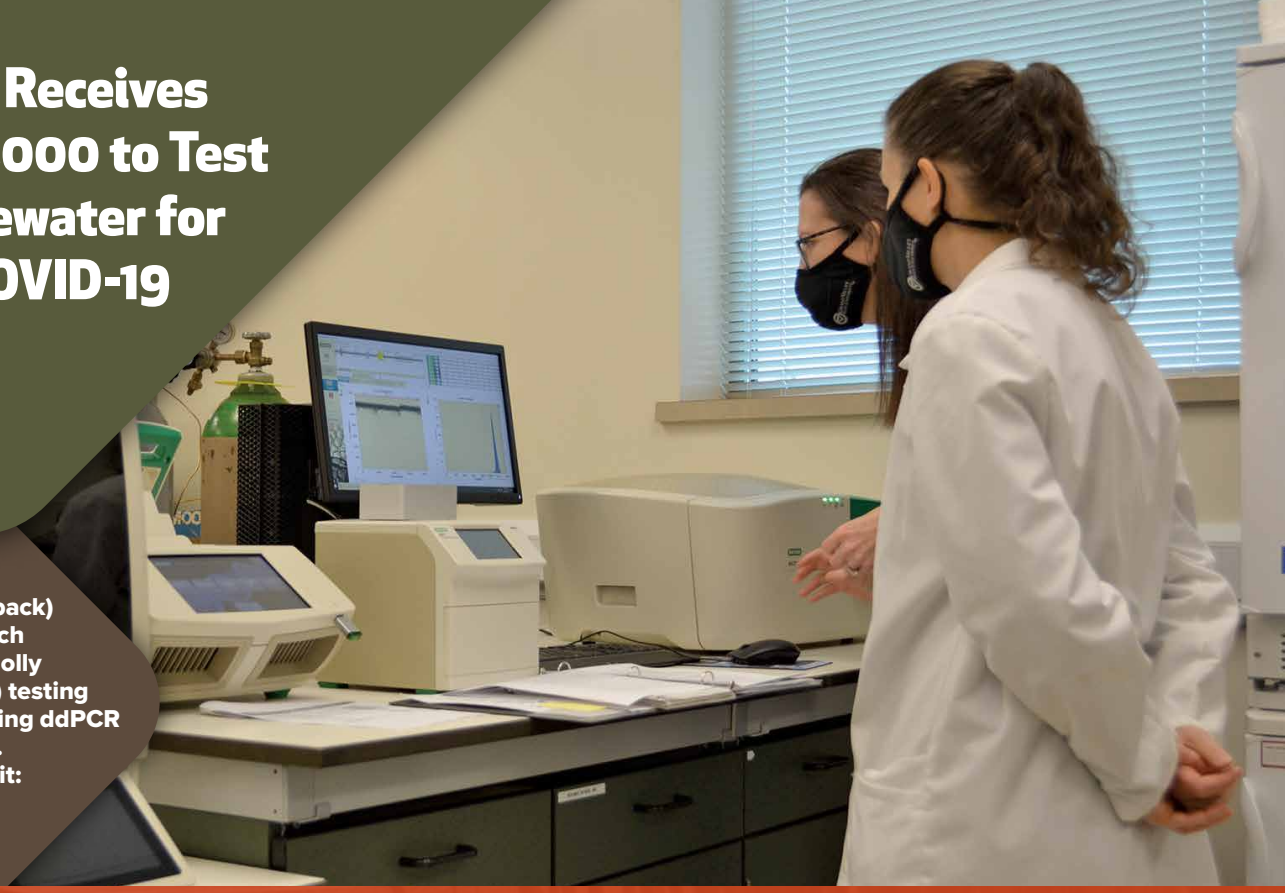
And for that second promise? Well, I can say with a high level of confidence that 2021 will be filled with more change. Some of it can be anticipated and some will likely knock us for a loop. Either way, the faculty, staff, and students populating the Robert B. Annis Water Resources Institute will come prepared, allowing us to continue our mission of integrating research, education, and outreach to protect and preserve our water resources, as evidenced in the following pages of our 2020 Year in Review.

Thank you, as always, for your interest and support.



Alan Steinman
Allen I. and Helen J. Hunting Director, AWRI

AWRI Receives $500,000 to Test Wastewater for the COVID-19 Virus



Dr. Charlyn Partridge (back) and research assistant Molly Lane (front) testing samples using ddPCR instrument. Photo Credit: Brian Scull.

AWRI received a $318,000 grant from the Michigan Department of Environment, Great Lakes, and Energy to conduct SARS-CoV-2 virus testing in wastewater. The Wastewater Pilot Study is funded by a $10 Million Coronavirus Aid, Relief, and Economic Security Act grant to the State of Michigan to establish a standardized and coordinated monitoring network of 17 laboratories to enhance pandemic response. AWRI also received under a separate agreement a $191,000 digital droplet Polymerase Chain Reaction (ddPCR) instrument to conduct the testing. Wastewater testing can serve as a reliable method to screen for COVID-19 infections in populations or facilities, as individuals will excrete the virus a week before symptoms are expressed. AWRI will test wastewater samples from Ottawa and Muskegon Counties and provide results to state and local Health Departments. The project team includes AWRI's Dr. Richard Rediske, Dr. Charlyn Partridge, Molly Lane, Brian Scull, and Dr. Kevin Strychar in addition to Dr. Shelia Blackman and Dr. Pei-Lan Tsou from GVSU's Cell and Molecular Biology Department.

Jerry Lamb's Passing

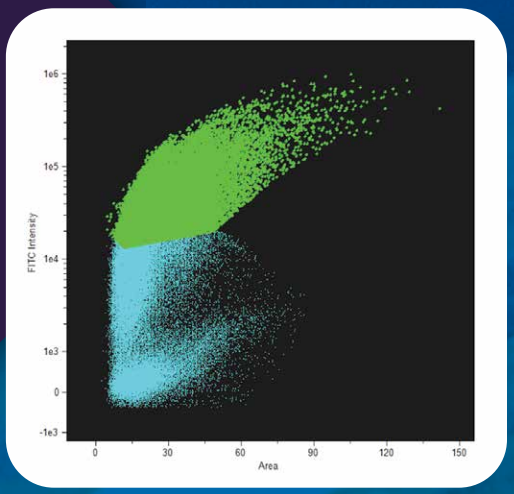
Jerry Lamb passed away 9/20/2020. A registered nurse, community advocate, and director of Ottagan Addiction Recovery, Inc., Lamb and her husband Leonard were long-time supporters of AWRI and Leonard captained AWRI's first research and education vessel, the *Angus*. Mrs. Lamb's estate is providing funding to support an undergraduate student intern in Summer 2021.

Kay Jackson's Passing

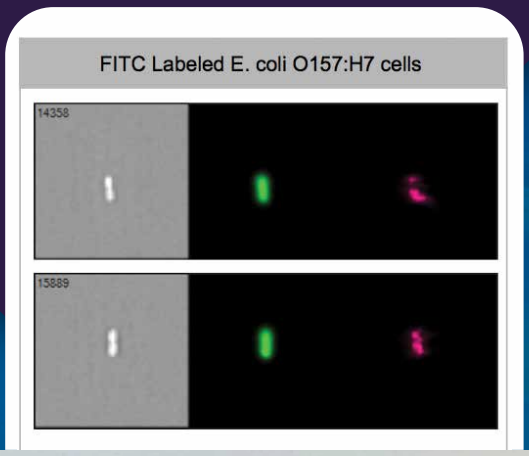
Kathleen (Kay) Jackson passed away 9/11/2020 at the age of 97. With her husband, Dr. William (Bill) Jackson, the Jacksons were life-long supporters of AWRI and foundational to its long-term success. They created a challenge grant to build a new research vessel (named the *W.G. Jackson* after Bill) and established funds at the Community Foundation *for* Muskegon County to support long-term monitoring, research, and education on Muskegon Lake.

Tracking Pathogens in Food Crops

Global environmental changes, caused by both natural and human activities, have accelerated over the last two centuries. Pathogens are coupled to these changes; however, the "out of sight and out of mind" concept is quickly catching many of us off guard as food crops are increasingly affected, human infections increase, and hospitals become overloaded with the sick. AWRI's Dr. Kevin Strychar is studying agricultural safety in Michigan, examining the concentrations at which *E. coli* exists in crop irrigation water and in particular, the presence/absence of *E. coli* O157:H7 – a human pathogen that causes severe diarrhea, sometimes kidney damage, and occasionally death. Using Imaging Flow Cytometry, results are obtained in seconds rather than hours or days using more traditional methods.



Soil sample stained with FITC conjugated polyclonal *E. coli* antibodies and analyzed by image flow cytometer showing an average concentration of 8.87x10^5 cells/mL. Shown above is a dot-plot comparing stained vs not stained cells. Detected *E. coli* population indicated in green. Photo Credit: Darrick Gates.



Human pathogen *E. coli* serotype O157:H7. Black and white photo shows pathogen without stain, green color shows population stained with FITC conjugated monoclonal antibody, pink color shows differential stain. Each parameter (no stain, green and pink stain) is used for rapid detection of pathogens using imaging flow cytometry. Photo Credit: Darrick Gates.

AWRI Completes its 20th Year of Beach Monitoring

Intern Maggie Brenneman (left) and GVSU Public Health graduate student Alexis Porter (right) conduct a beach survey. Photo Credit: Valerie Hendrickson.

AWRI celebrated its 20th year of performing beach water quality monitoring for Public Health Muskegon County. The program began in 2001 culturing *E. coli* on petri dishes and has transitioned to advanced molecular biology methods using quantitative Polymerase Chain Reaction (qPCR) methods. AWRI is monitoring *E. coli* concentrations with traditional and molecular based methods in addition to looking for human and animal markers to determine the source of contamination.

Tracking Sources of Contamination

AWRI started a study of the Pigeon River with the Ottawa Conservation District to determine the source of high bacteria and nutrient levels. The Rediske Lab will also be looking at human DNA markers from failing septic systems.

GVSU Public Health graduate student Alexis Porter conducts a phosphorus analysis. Photo Credit: Brian Scull.

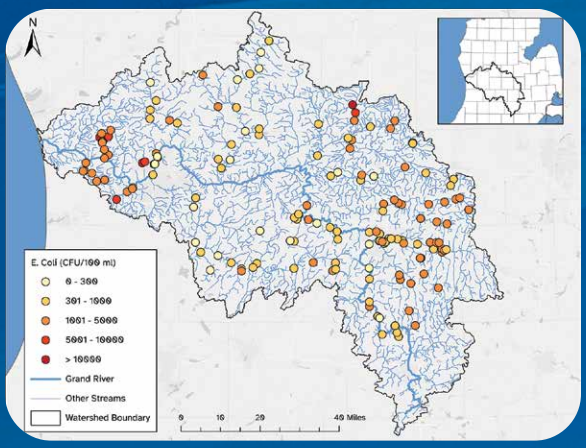
Is Sediment a Source of Phosphorus in Muskegon Lake?

GVSU undergraduate intern Hannah Shorkey (left) and research assistant Maggie Oudsema (right) prepare a sediment core. Photo Credit: Mike Hassett.

Recent samples from bottom waters in Muskegon Lake reveal an upward trend in phosphorus concentration during summer months. This often is an indication that phosphorus is being released from lake sediment, a process called internal phosphorus loading (IPL). Excess phosphorus can stimulate algal blooms, causing water quality impairments, restricting recreational activity, and negatively impacting economic vitality in the region. If phosphorus concentrations exceed the restoration target for Muskegon Lake, this may prevent the Lake's de-listing as a Great Lakes Area of Concern, which is currently scheduled for some time in 2021. The Steinman Lab received funding from NOAA to measure phosphorus release from the sediments this summer; these data will help determine if control measures are needed to limit IPL in Muskegon Lake.

Mapping *E. coli* Hotspots in the Grand River

E. coli contamination of streams is a major concern because of the potential human health impacts. Understanding both where contamination occurs and the causes of contamination poses logistical difficulties in large river systems. Dr. Sean Woznicki and technician Jacob Weston are using geospatial data (e.g., locations of septic systems and land-applied manure) coupled with Michigan's catalogue of in-stream *E. coli* samples, to estimate *E. coli* concentrations for all streams in the Grand River watershed.



In-stream *E. coli* samples in the Grand River watershed. These data are the foundation of the geostatistical models. Photo Credit: Jacob Weston.

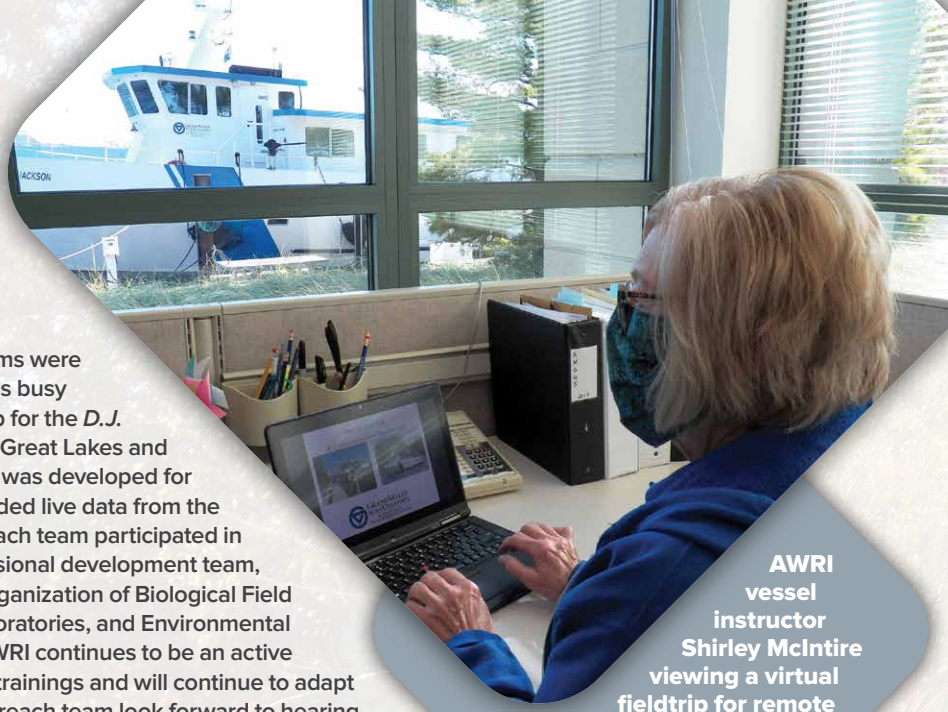
Steinman Appointment to GLAB

Dr. Al Steinman was appointed to the newly re-constituted Great Lakes Advisory Board (GLAB). In that capacity, Steinman and 13 other appointees from throughout the Great Lakes Basin will provide advice and recommendations to the US Environmental Protection Agency on matters related to the Great Lakes Restoration Initiative (GLRI) and the implementation of the Great Lakes Water Quality Agreement between the US and Canada.

US EPA Administrator Andrew Wheeler (right) at AWRI announcing re-establishment of GLAB. Seated is Kurt Thiede, Regional Administrator for EPA Region 5. Photo Credit: Kendra Stanley-Mills.

Education and Outreach Adaptations to COVID-19

Although vessel-based and classroom programs were put on hold in 2020, the outreach program was busy with virtual offerings. For instance, a virtual lab for the *D.J. Angus* was developed for GVSU Biology 107 - Great Lakes and Other Water Resources. A laboratory exercise was developed for the *W.G. Jackson* as well. Part of this lab provided live data from the Muskegon Lake Buoy Observatory. The outreach team participated in the Groundswell Summer Institute and professional development team, GLOBE North American Regional Meeting, Organization of Biological Field Stations, National Organization of Marine Laboratories, and Environmental Education Training for Michigan educators. AWRI continues to be an active partner in Project WET and GLOBE via online trainings and will continue to adapt to changing times in 2021. Dr. Vail and her outreach team look forward to hearing from educators about how AWRI can help with their needs.



AWRI vessel instructor Shirley McIntire viewing a virtual fieldtrip for remote learning students. Photo Credit: Janet Vail.

Can Bacteria Pellets Eat Muck?

Several companies sell a commercial product composed of bacteria that is claimed to consume sediment organic matter on lake bottoms. This is a very appealing product to lakefront homeowners due to ease of application and relatively low cost. The question remains does it work? MSU Extension approached the Steinman Lab to answer this question, with funding from the Newaygo County Drain Commissioner's Office. Experiments examining the effect of temperature and oxygen content on pellet effectiveness are currently taking place, with results available in early 2021.

Experimental cores containing sediment and muck digester pellets; thin tubes are gas lines providing oxygen or a blend of nitrogen and carbon dioxide gasses. Photo Credit: Emily Kindervater.

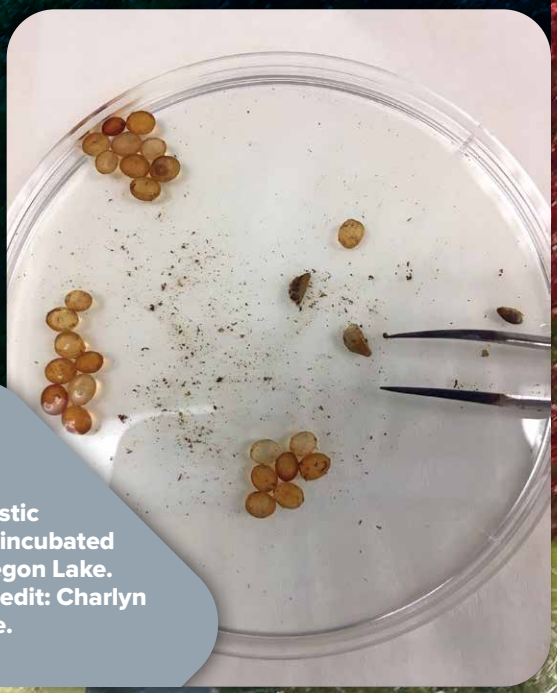
Vail Receives Service Award

For her 20 years as the Michigan Project WET (Water Education Today) coordinator, Dr. Janet Vail received the Blue Planet award at the national convention of Project WET and WILD (Wildlife In Learning Design).

Janet Vail at the Project WET 2017 annual conference she organized in Traverse City, MI.

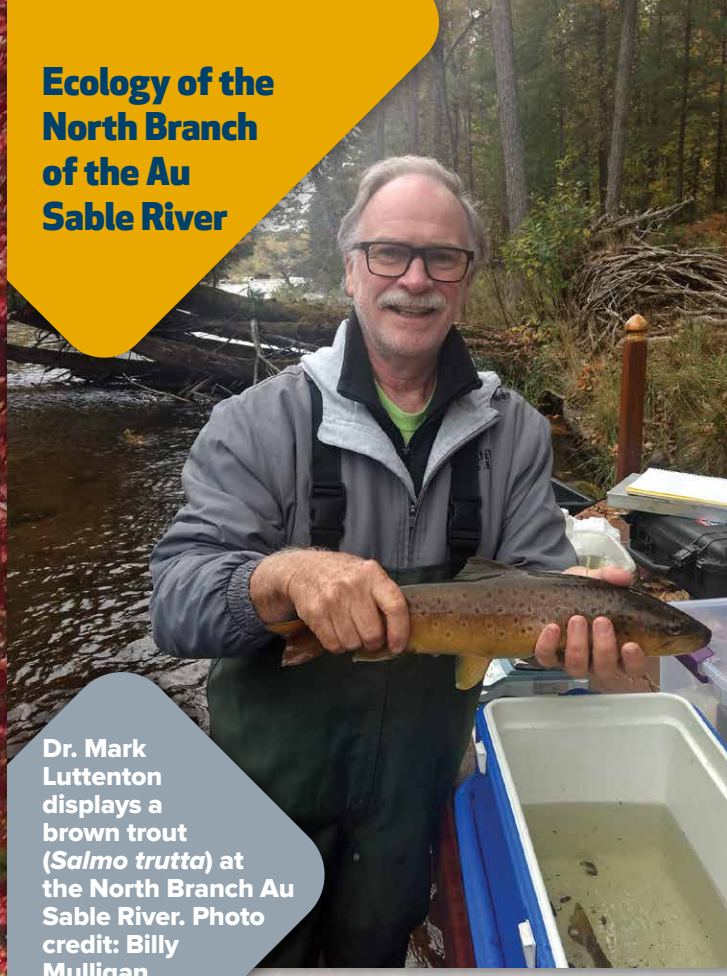
Microplastic Impacts on Aquatic Wildlife

The Partridge Lab is continuing work on microplastics to examine how ingestion of these small pollutants impact Great Lakes fish. Once microplastics reach aquatic ecosystems, microbial biofilms can form on their surface. If ingested, the microbial biofilms may alter the normal gut microbial community of fish, leading to long-term health implications. They will examine how ingestion of microplastics incubated in Muskegon Lake alter gut microbiomes of yellow perch, and assess their impact on growth and other health parameters.



Microplastic samples incubated in Muskegon Lake. Photo Credit: Charlyn Partridge.

Ecology of the North Branch of the Au Sable River



Dr. Mark Luttenton displays a brown trout (*Salmo trutta*) at the North Branch Au Sable River. Photo credit: Billy Mulligan.

The North Branch of the Au Sable River is a renowned trout fishery, but recent declines in trout populations have caused alarm among the fishing public. A recent trout survey conducted by Dr. Mark Luttenton found very few trout survive past the age of two. Working with Department of Biology graduate students Bert Carey and Paul Dingman, Dr. Luttenton is evaluating possible causes for the declines, including changes in invertebrate populations and habitat quality.

Kurt Thompson will be Sorely Missed

After 31 years of dedicated service to AWRI and GVSU, Kurt Thompson is taking early retirement to spend more time with family and friends. Kurt's infectious smile, expertise in IT and GIS, and overall positive attitude have brightened AWRI's atmosphere, increased our productivity immeasurably, and assisted literally hundreds of student, faculty, and staff for more than three decades. We wish him all the best in the future and he will always be welcome at AWRI (especially when we have IT issues)!

Using Airborne eDNA to Track an Invasive Pest

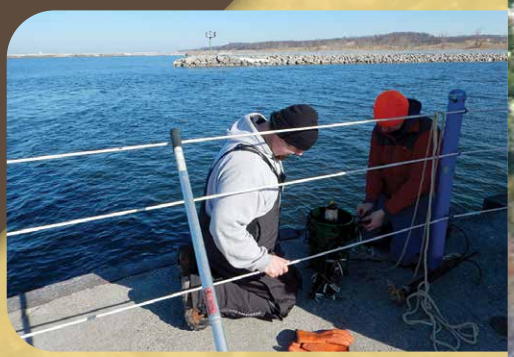
Invasive species are a continual threat to the Great Lakes region. Early detection of invasive species is extremely important for natural resource managers, as this allows for a quick response to control and eradicate these pests. The Partridge Lab is developing a modified airborne environmental DNA (eDNA) method that can be used as an early monitoring approach for the invasive insect, hemlock woolly adelgid (HWA). HWA is a primary threat to the health of hemlock forests along Michigan's coastal areas. The Partridge Lab has constructed traps to capture airborne HWA material and is developing a molecular assay for rapid HWA detection. Over the next year, the lab will be evaluating the effectiveness of the trap within Michigan hemlock stands. This technology will lead to earlier detection of this invasive pest and help preserve valuable personnel resources for HWA eradication and treatment efforts in Michigan.

Hemlock woolly adelgid ovisacs on a hemlock branch. Photo Credit: Meg Sanders.

A trap for collecting airborne hemlock woolly adelgid eDNA from hemlock forests. Photo Credit: Meg Sanders.

Muskegon Lake is Home Sweet Home

Lake sturgeon (*Acipenser fulvescens*) are Michigan's largest native fish. Once abundant in Lake Michigan and its tributaries, the species is now considered threatened. A multi-year study by AWRI of the whereabouts of lake sturgeon found that adults use Muskegon Lake throughout the year and not just as a staging habitat during the spring spawning migration in the Muskegon River. This study builds on previous research by AWRI that showed Muskegon Lake is an important nursery habitat for juvenile lake sturgeon.



AWRI researchers Brandon Harris (left) and Travis Ellens (right) inspect an acoustic tag receiver. Photo Credit: Andrya Whitten.

Travis Ellens holds a lake sturgeon captured in Muskegon Lake. Photo Credit: Brandon Harris.

A Decade of Coastal Wetlands Monitoring

AWRI completed 10 years of ecological monitoring of Great Lakes coastal wetlands as part of an international collaborative effort, funded by the Great Lakes Restoration Initiative, and involving universities, private partners, and government agencies to document status and trends in the ecological condition of wetlands.

Intern Matthew Silverhart holds a pumpkinseed (*Lepomis gibbosus*). Photo Credit: Travis Ellens.

A fyke net used to sample fish in a Great Lakes coastal wetland. Photo Credit: Travis Ellens.

Grayling Restoration Geared for Success

The arctic grayling (*Thymallus arcticus*) was once Michigan's dominant stream salmonid in the Lower Peninsula. The species was extirpated from Michigan by the late 1930s due to logging of the White Pine forest, overharvest, and introduction of non-native trout. Recent successes in restoring arctic grayling in Montana using streamside incubators has renewed interest in re-establishing the species in Michigan. The main advantage of streamside incubators compared to traditional hatchery techniques is that fertilized eggs are reared in the water from streams where fish will be stocked, allowing acclimation to natural conditions and imprinting on chemical signatures of the stream. Graduate thesis research by AWRI alumnus Alan Mock (now a Ph.D. candidate at Florida International University) showed that streamside incubators can be used successfully in Michigan streams and makes recommendations about best practices for implementation. The study was done in collaboration with the Little River Band of Ottawa Indians and was published in *North American Journal of Fisheries Management*.

Alan Mock with a streamside incubator at Peterson Creek, a tributary of the Manistee River. Photo Credit: Carl Ruetz.

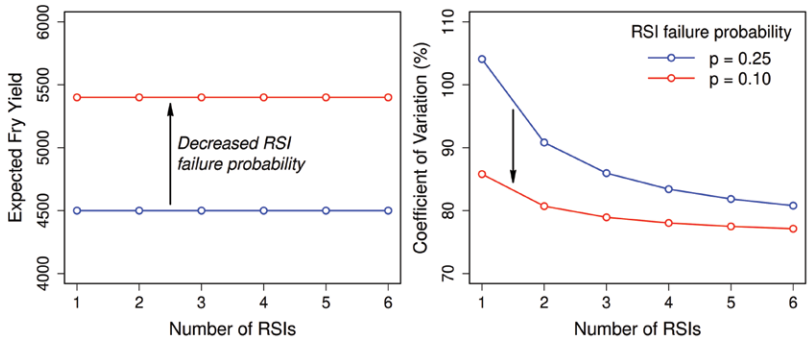
Molecular Mechanisms Impact Invasion Success

The Partridge Lab is closing in on the molecular processes that allow invasive baby's breath (*Gypsophila paniculata*) to successfully invade Michigan's coastal sand dunes. A recent study comparing invasive populations across habitats has found that Michigan populations upregulate genes associated with nutrient starvation to survive in this nutrient-limited habitat.

Invasive baby's breath within Michigan's sand dunes system. Photo Credit: Charlyn Partridge.

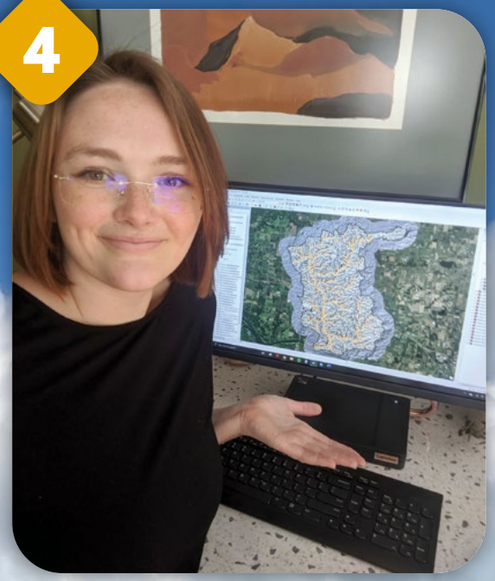
Modeling to Predict Fry Production: Don't Put All Your Fish Eggs in One Basket

If all fish eggs are placed within a single remote site incubator (RSI), no fry will emerge if the RSI fails. Using multiple RSIs reduces this outcome uncertainty, but how many are needed? Drs. Jim McNair and Carl Ruetz developed a mathematical model for guidance that shows the expected fry yield (number emerging) increases as the failure probability of RSI declines through good design and maintenance. Using more than one RSI also decreases yield uncertainty, with two or three typically being adequate.



Increasing the number of RSIs doesn't directly change expected fry yield (left) but does decrease yield uncertainty, as measured by the coefficient of variation (right). Decreasing RSI failure probability both increases expected fry yield and decreases yield uncertainty (arrows). Photo Credit: Jim McNair.

AWRI AT WORK



1 Graduate student Katy Sheets measuring water quality in Ottawa Sands Park.

2 Undergraduate student Maggie Brenneman conducting a qPCR test.

3 Undergraduate student Matthew Silverhart in a Lake Michigan coastal wetland.

4 Undergraduate student Megan Urquhart's ArcGIS tools of the Deer Creek watershed.

5 Science Instructor Shirley McIntire sampling phytoplankton in Muskegon Lake.

6 AWRI Fall 2020 new graduate students (L to R): Maggie Petersen, Alexis Porter, Ellen Foley, Nick Vander Stelt, Jonathan Walt, Nate Dugener.

7 Graduate student Tyler Harman displays a section of northern star coral.

8 Graduate student Megan Mader with a Chinook salmon (*Oncorhynchus tshawytscha*) found during electrofishing.

9 Graduate student Meg Sanders with sampling gear for hemlock wooly adelgid.

10 Adjunct research assistant Emily Kindervater piloting a jonboat.

11 Research assistant Maggie Oudsema sampling water quality via kayak.

Photo Credit: Travis Ellens

Star Wars: Studies of an Aquatic Invasive Species, Starry Stonewort

Graduate student Emily Neuman is working with Dr. Sarah Hamsher to study the growth of the invasive macroalga, starry stonewort (*Nitellopsis obtusa*), in Pentwater and Muskegon Lakes. Starry stonewort is a green macroalga native to Europe and Asia. It is considered invasive in North America due to being an aggressive competitor in aquatic systems that, once established, forms thick monotypic meadows that could negatively impact native macrophyte communities. However, little is known of these impacts. Emily's research will record the timing of the peak biomass of starry stonewort in Pentwater and Muskegon Lakes to aid in the management of this invasive species, assisting in addressing the uncertainties of the growth of starry stonewort and aid managers in determining best management practices.

Additionally, Emily and Dr. Hamsher are working with Dr. Sean Woznicki (AWRI) to use species distribution modeling to combine data from the Starr Virtual Herbarium, Global Biodiversity Information Facility, and LAGOS (LAke multi-scaled GeOSpatial) databases to predict and identify conditions suitable for starry stonewort, allowing agencies to develop preventive early detection plans and reduce the spread of this invasive macroalga.

Closeup of starry stonewort (*Nitellopsis obtusa*). Photo Credit: Sarah Hamsher.

Neuman Earns Research Grant

Emily Neuman was awarded the Lake Research Student Grant from the Michigan Chapter, North American Lake Management Society (McNALMS) and Michigan Lakes and Streams Association (MLSA) to study the aquatic invasive species, starry stonewort (*Nitellopsis obtusa*).

Graduate student Emily Neuman with a handful of starry stonewort (*Nitellopsis obtusa*). Photo credit: Sarah Hamsher.

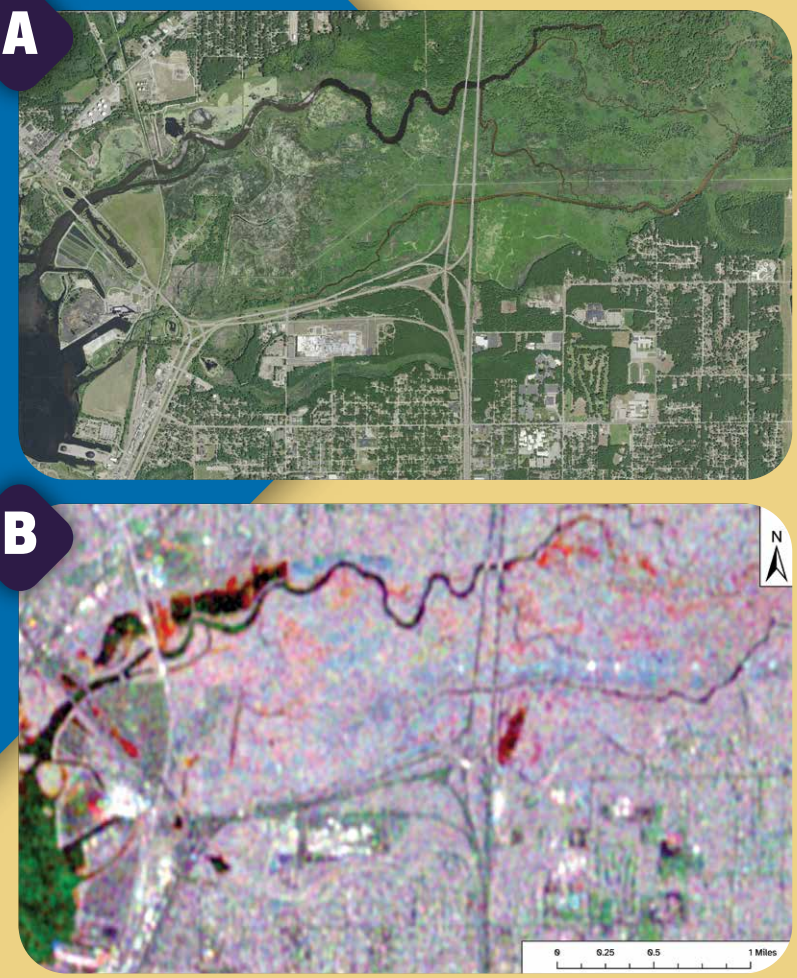
Aquatic Invasive Species in Higgins Lake

Although resource managers continually warn against introducing aquatic invasive species into lakes, preventing their spread is nearly impossible, and eradication after an introduction is generally not feasible. Continuing his work in Higgins Lake, Dr. Mark Luttenton tracked the spread of two recently discovered aquatic invasive species, starry stonewort and the quagga mussel. Originally found in isolated locations, both species have rapidly spread throughout much of Higgins Lake in just one year.

Graduate student Billy Mulligan samples deep sediments through the ice at Higgins Lake. Photo credit: Mark Luttenton.

Wetlands on Our Radar

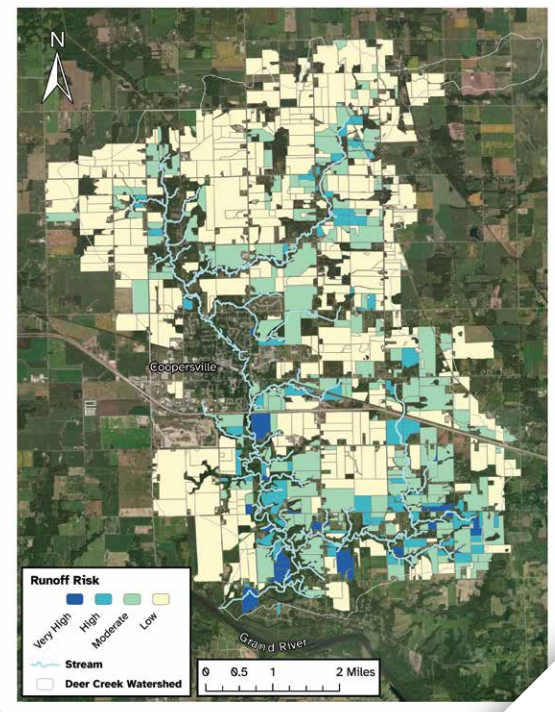
Wetlands are important components of our landscape, performing valuable functions like retaining floodwater and supporting a vast array of wildlife. Understanding how these dynamic ecosystems become inundated or desiccated is important because water is a significant pathway for the flow of energy and organisms across landscapes. Dr. Sean Woznicki received a grant from the Michigan Space Grant Consortium to map wetland connectivity via wetting using satellite remote sensing. Dr. Woznicki and graduate student Jonathan Walt are using the European Space Agency's Sentinel-1 synthetic aperture radar (SAR) satellite to map wetland inundation over time and space. SAR is unique because it can "see" the Earth's surface through clouds and penetrate through forest canopy, making it ideal to identify flooding. By measuring the strength of the radar return signal, they can identify standing water in wetland landscapes and map wetlands' dynamic surface water conditions.



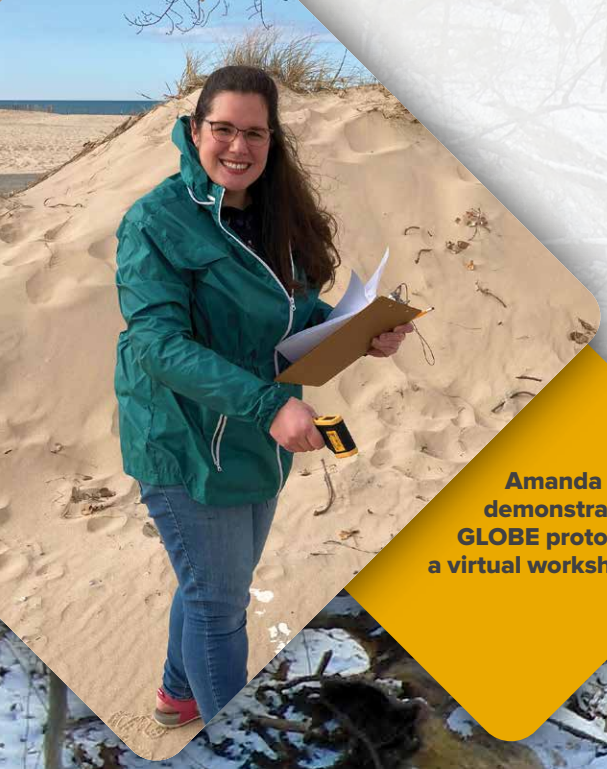
Wetlands upstream of Muskegon Lake, comparing (A) an aerial image and (B) a multi-date SAR image, where black shows permanent surface water, bright red indicates completely inundated vegetation and pale blue represents partially flooded vegetation. Photo Credit: Jonathan Walt and Jacob Weston.

Precision Conservation in Deer Creek

AWRI undergraduate intern Megan Urquhart is working with Dr. Sean Woznicki to identify and map agricultural fields for implementing conservation practices based on their risk of delivering sediment and nutrients to streams. Megan is using high-resolution LiDAR-derived topography and the Agricultural Conservation Planning Framework (ACPF) to develop these maps.



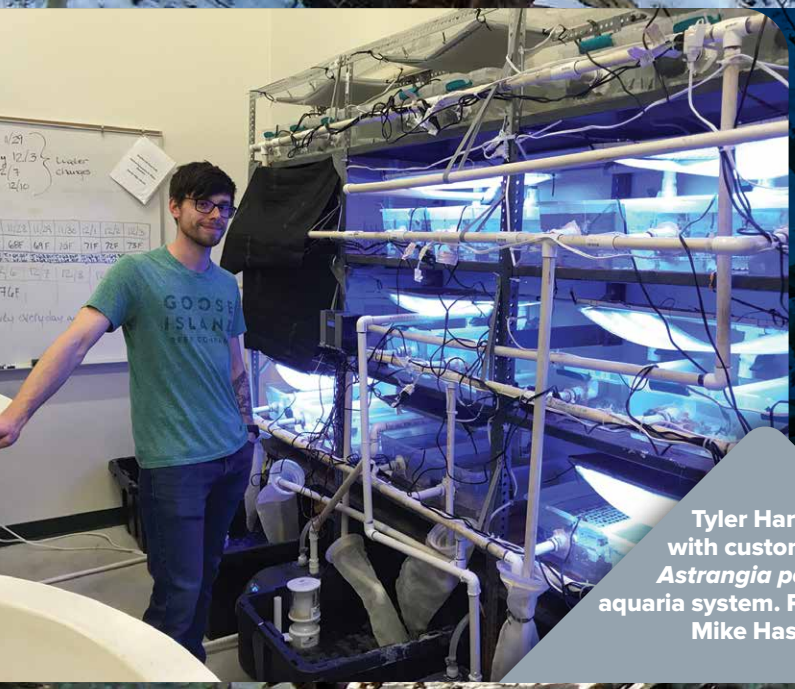
Deer Creek watershed farm fields identified by high runoff category using ACPF. Photo Credit: Megan Urquhart.



Amanda Syers demonstrating a GLOBE protocol for a virtual workshop.

Michigan Space Grant Project on Climate Change Education

Dr. Janet Vail and science education specialist Amanda Syers are partnering with Dr. Elena Lioubimtseva on a Michigan Space Grant Consortium Project called Michigan Resources for Climate and Land Cover Change Education (MiRCLE). The project engages a team of teachers in long-term professional development, resulting in lesson plans on climate change and land cover for middle school and high school. The teachers participated in seminars such as the Climate Change Education Solutions Summit (CCESS2020) and NASA Global Learning and Observations to benefit the Environment (GLOBE) training.



Tyler Harman with custom-built *Astrangia poculata* aquaria system. Photo Credit: Mike Hassett.

Effects of Climate Change on Cold-Water Temperate Coral

Although global warming and cooling are natural components of Earth's history, the increased frequency and duration of warming trends observed over the past century have created concerns whether organisms can adapt or acclimate; temperate aquatic organisms are understudied in this field. Graduate student Tyler Harman conducted stress simulations on *Astrangia poculata*, a temperate coral he found to be thermally resistant and not affected by disease; these results are encouraging but they are the first immunity studies conducted on this coral. Additional immunity pathway studies will determine the level of resistance.

Climate Change and Water Levels of Lake Michigan

Great Lakes high water levels in 2020 broke records and caused thousands of dollars in property damage. With future water levels expected to change more rapidly than in the past, Dr. Kevin Strychar appeared with other key experts at a "Lake Michigan & Waterfront Erosion 2020" conference to address public concerns.

Dr. Kevin Strychar (center) speaking at the conference panel. Photo Credit: Coldwell Banker Woodland Schmidt.

Hypoxia Trends: Deep, Dark, and De-Oxygenated

Nate Dugener (left) and Tony Weinke (right) service the multi-parameter sensor array on the Muskegon Lake Observatory gvsu.edu/buoy. Photo Credit: Bopi Biddanda.

While bottom water hypoxia (oxygen depletion) is a natural, recurring phenomenon in Muskegon Lake, its severity depends on numerous environmental (e.g., air temperature, weather events) and anthropogenic (e.g., phosphorus loading, climate change) factors. The onset and expansion of hypoxia result in potentially serious ecological impairments. Further, episodic intrusions of oxygenated cold water from Lake Michigan can disrupt Muskegon Lake hypoxia, causing it to be highly dynamic in space and time. Undergraduate student Ian Stone analyzed a decade of hypoxia data from the Muskegon Lake Observatory and found high interannual variability with a decreasing frequency of hypoxia throughout the decade. Years in which the intensity and days of hypoxia were the most severe coincided with heightened spring air temperatures as well as reduced bottom water temperatures, suggesting an association between stronger thermal stratification and more persistent hypoxia. The study also revealed an encouraging trend of reduction in hypoxia duration in recent years.

Microbial Tango: Dancing in the Mat World

In the sinkholes of Lake Huron, alternating waves of purple cyanobacteria and white chemosynthetic microbes rise to the sediment surface during the day and night, respectively. Such a synchronized diurnal "tango" might have been the largest daily mass movement of life on the Precambrian seafloor billions of years ago, optimizing photosynthesis and chemosynthesis – and oxygenating the early biosphere.

Underwater time-lapse camera monitors the diurnal migration of mat microbes in the Middle Island Sinkhole, Lake Huron. Photo Credit: Phil Hartmeyer, NOAA.

How Diatoms Ruled in 2019: All Blooms are Not the Same

The Muskegon Lake watershed saw record-breaking precipitation and unusually cool temperatures in 2019. While the main concern regarding the effects of land use and climate change on phytoplankton is the proliferation of cyanobacterial blooms, graduate student Jasmine Mancuso found that diatoms dominated Muskegon Lake under 2019's cool and rainy conditions. This unprecedented scenario in Muskegon Lake offers insight into an alternative effect of regional climate change on the phytoplankton community with attendant effects on the ecosystem.

A summer 2019 algal bloom on Muskegon Lake. Photo Credit: Jasmine Mancuso.

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- Eric Hecox, Lead Captain WGJ and Relief Captain DJA
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- Tim Lucas, Relief Captain DJA
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- Brian Scull, Laboratory Supervisor
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- 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
- Renée Tardani, Technical Call-in

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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
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- Cassidy Gilmore
- Tyler Harman
- Jennifer Kovacs

Woznicki, major advisor
- Jonathan Walt, AWRI Assistantship

Internships & Scholarships

AWRI provides opportunities for students to pursue their interests in our environment. The following students received internships during 2020.

Herbert VanderMey Intern:
Anahi Huitron

Robert B. Annis Foundation Interns:
Maggie Brenneman
Kathryn Geller
Hannah Shorkey
Matthew Silverhart

AWRI Interns:
Brooke Keck
Megan Urquhart

Bill and Diana Wipperfurth Scholarship:
Megan Urquhart

Ron Ward Scholarship:
Gracie Endres
Beck Lukins
Riley Sokolowski
Ethan Vink
Zane Walters

Student Summer Scholar (S3):
Hailey Kuhnle

NASA Michigan Space Grant Consortium Summer Intern:
Ian Stone

Photo Credit: Travis Ellens

Peer Reviewed Publications

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

Antonelli, P.L., S.F. Rutz, and **K.B. Strychar**. In Press. Heat stress on scleractinian corals: its symbionts in evolution. Nonlinear Analysis: Real World Applications. https://www.reasearchgate.net/publications/335887569

Dumke, J.D., **G.M. Chorak****, **C.R. Ruetz III**, R.A. Thum, and **J.N. Wesolek****. 2020. Identification of black bullhead (*Ameiurus melas*) and brown bullhead (*A. nebulosus*) from the western Great Lakes: recommendations for small individuals. American Midland Naturalist. 183(1): 90-104. doi: 10.1637/19-041

Gezon, N.R.**, D.W. Haywick, J.M. Sanders, I. Hewson, and **K.B. Strychar**. 2020. Circular *Rep* encoding single stranded (CRESS) DNA virus-like sequences detected in quagga mussels (*Dreissena rostriformis bugenis*) and sediments from the central Lake Michigan benthos. Journal of Great Lakes Research. 46: 302-310. doi: 10.1016/j.jglr.2020.01.011

Hamsher, S.E., K. Ellis, D. Holen, and R.W. Sanders. 2020. Effects of light, dissolved nutrients and prey on ingestion and growth of a newly identified mixotrophic alga, *Chrysolepidomonas dendrolepidota* (Chrysophyceae). Hydrobiologia. 847: 2923-2932. doi: 10.1007/s10750-020-04293-z

Harris, B.S.**, **C.R. Ruetz III**, **T.J. Ellens****, **A.D. Weinke****, and **Biddanda, B.A.** 2020. Adult lake sturgeon (*Acipenser fulvescens* Rafinesque, 1817) occurrence in the Muskegon River system, a Lake Michigan drowned river mouth, USA. Journal of Applied Ichthyology. 36: 547-558. doi: 10.1111/jai.14076

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. 2020. A basin-wide survey of coastal wetlands of the Laurentian Great Lakes: development and comparison of water quality indices. Wetlands. 40: 465-477. doi: 10.1007/s13157-019-01198-z

Hernandez-Suarez, J.S., **S.A. Woznicki**, and A.P. Nejadhashemi. 2019. Multi-site watershed model calibration for evaluating best management practice effectiveness in reducing fecal pollution. Human and Ecological Risk Assessment: An International Journal. doi: 10.1080/10807039.2019.1680526

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

Jenny, J.P., O. Anneville, F. Arnaud, Y. Baulaz, D. Bouffard, I. Domaizon, S.A. Bocaniov, N. Chèvre, M. Dittrich, J.M. Dorioz, E. Dunlop, G. Dur, J. Guillard, T. Guinaldo, S. Jacquet, A. Jamoneau, Z. Jawed, E. Jeppesen, G. Krantzberg, J. Lenters, B. Leoni, M. Meybeck, V. Nava, T. Nõges, P. Nõges, M. Patelli, V. Pebbles, M.E. Perga, S. Rasconi, **C.R. Ruetz III**, L. Rudstam, N. Salmaso, S. Sapna, D. Straile, O. Tammeorg, M.R. Twiss, D.G. Uzarski, A.M. Ventela, W.F. Vincent, S.W. Wilhelm, S.Å. Wängberg, and G.A. Weyhenmeyer. 2020. Scientists' warning to humanity: rapid degradation of the world's large lakes. Journal of Great Lakes Research. 46(4): 686-702. doi: 10.1016/j.jglr.2020.05.006

Lamar, S.K.**, and **C.G. Partridge**. 2020. Combining herbarium databases and genetic methods to evaluate the invasion of a popular horticultural species, baby's breath (*Gypsophila paniculata*), in the United States. Biological Invasions. doi: 10.1007/s10530-020-02354-x

Lamar, S.K.**, I. Beddows, and **C.G. Partridge**. 2020. Examining the molecular mechanisms contributing to the success of an invasive species across different ecosystems. Ecology and Evolution. doi: 10.1002/ece3.6688

Lane, M.J.**, **J.N. McNair**, **R.R. Rediske**, S. Briggs, M. Sivaganesan, and R. Haugland. 2020. Simplified analysis of measurement data from a rapid *E. coli* qPCR method (EPA Draft Method C) using a standardized excel workbook. Water. 12(3): 775. doi: 10.3390/w12030775

Lane, M.J.**, **R.R. Rediske**, **J.N. McNair**, S. Briggs, G. Rhodes, E. Dreelin, T. Sivy, M. Flood, **B. Scull**, D. Szlag, B. Southwell, N.M. Isaacs, and S. Pike. In Press. A comparison of *E. coli* concentration estimates quantified by the U.S. EPA and a Michigan laboratory network using U.S. EPA Draft Method C. Journal of Microbiological Methods. doi: 10.1016/j.mimet.2020.106086

Lei, Y., **A.D. Steinman**, W. Xiang, S. Xiubo, and L. Xie. 2019. A new method based on diffusive gradients in thin films for in situ monitoring microcystin-LR in waters. Scientific Reports. 9: 17528. doi: 10.1038/s41598-019-53835-6

Leimbach-Maus, H.**, E. McCluskey, A. Locher, **S.R. Parks**, and **C.G. Partridge**. 2020. Genetic structure of invasive baby's breath (*Gypsophila paniculate L.*) populations in a Michigan dune system. Plants. 9(9): 1123. doi: 10.3390/plants9091123

Mock, A.J.**, **C.R. Ruetz**, **J.N. McNair**, D. Mays, and A. Martell, A. In Press. Evaluating remote site incubators in Michigan streams: implications for Arctic Grayling reintroduction. North American Journal of Fisheries Management. doi: 10.1002/nafm.10534

Myers, D.T.L.**, **R.R. Rediske**, **J.N. McNair**, and **M.E. Allen****. 2020. Watershed and streambank erosion modeling in a coldwater stream using the GWLF-E model: application and evaluation. Modeling Earth Systems and Environment. doi: 10.1007/s40808-020-00882-y

Rice, E.K.**, **H. Leimbach-Maus****, **C. Partridge**, and **J.N. McNair**. 2020. Assessment of invasive *Gypsophila paniculata* control methods in the northwest Michigan dunes. Invasive Plant Science and Management. 13(2): 94-101. doi: 10.1017/inp.2020.10

Schmidt, M.L., **B.A. Biddanda**, **A.D. Weinke****, E. Chiang, **F. Januska***, R. Props, and V.J. Denef. 2020. Microhabitats are associated with diversity–productivity–function relationships in freshwater bacterial communities. FEMS Microbiology Ecology. 96(4): fiaa029. doi: 10.1093/femsec/fiaa029

Senegal, T J., **C.R. Ruetz III**, **G.M. Chorak****, D.J. Janetski, D.F. Clapp, G.J. Bowen, and T.O. Höök. 2020. Differential habitat use patterns of yellow perch *Perca flavescens* in eastern Lake Michigan and connected drowned river mouth lakes. Journal of Great Lakes Research. 46(5): 1412-1422. doi: 10.1016/j.jglr.2020.06.021

Skutnik, J.E.**, S. Otieno, S.K. Khoo, and **K.B. Strychar**. 2020. Examining the effect of heat stress on *Montastraea cavernosa* (Linnaeus 1767) from a Mesophotic Coral Ecosystem (MCE). Water. 12(5): 1303. doi: 10.3390/w12051303

Steinman, A.D. and **E. Kindervater**. In Press. Ecosystem restoration in the Everglades and Great Lakes ecosystems: past, present, and future preventive management. Inland Waters.

Steinman, A.D., J. Scott, L. Green, **C. Partridge**, **M. Oudsema**, **M. Hassett**, **E. Kindervater**, and **R. Rediske**. 2020. Persistent organic pollutants, metals, and the bacterial community composition associated with microplastics in Muskegon Lake (MI). Journal of Great Lakes Research. 46(5): 1444-1458. doi: 10.1016/j.jglr.2020.07.012

Strychar K.B., and P.W. Sammarco. 2019. Tropical marine and brackish ecosystems. In: Climate change and non-infectious fish disorders. Eds: Patrick TK Woo and George K. Iwama. Wallingford, Oxfordshire, UK: Centre for Agriculture and Bioscience International.

Wan, X., **A.D. Steinman**, Y. Gu, G. Zhu, X. Shu, Q. Xue, W. Zou, and L. Xie. 2020. Occurrence and risk assessment of microcystin and its relationship with environmental factors in lakes of eastern plain ecoregion, China. Environmental Science and Pollution Research. doi: 10.1007/s11356-020-10384-0

Wan, X., **A.D. Steinman**, X. Shu, Q. Cao, L. Yao, and L. Xie. 2019. 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**. 2019. Influence of episodic wind events on thermal stratification and bottom water hypoxia in a Great Lakes estuary. Journal of Great Lakes Research. 45(6): 1103-1112. doi: 10.1016/j.jglr.2019.09.025

Woznicki, S.A., P. Cada, J. Wickham, M. Schmidt, J. Baynes, M. Mehaffey, and A. Neale. 2020. Sediment retention by natural landscapes in the conterminous United States. Science of the Total Environment. 745: 140972. doi: 10.1016/j.scitotenv.2020.140972

Xue, Q., **A.D. Steinman**, L. Xie, L. Yao, X. Su, Q. Cao, Y. Zhao, and Y. Cai. 2020. Seasonal variation and potential risk assessment of microcystins in the sediments of Lake Taihu, China. Environmental Pollution. 259: 113884. doi: 10.1016/j.envpol.2019.113884

Zhang, M., **A.D. Steinman**, Y. Xu, Q. Xue, Y. Zhao, and L. Xie. 2020. Effects of erythromycin and sulfamethoxazole on *Microcystis aeruginosa*: cytotoxic endpoints, production and release of microcystin-LR. Journal of Hazardous Materials. 399: 123021. doi: 10.1016/j.jhazmat.2020.123021

Non-Peer Reviewed Publications

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

Biddanda, B. 2020. A freshwater science refresher. A book review of "Freshwater Ecology: Concepts and Environmental Applications in Limnology", 3rd edition, by W. Dodds and M. Whiles, Academic Press, 2019. Lakes Letter, winter 2020, p. 11. http://iaglr.org/lakesletter/

Biddanda, B. 2020. Buoy completes a decade of lake observing science. Postcard from the field, Eos, American Geophysical Union, November 10, 2020. https://americangeophysicalunion.tumblr.com/post/634436656824483840/buoy-completes-a-decade-of-lake-observing-science

Biddanda, B. 2020. Lake observing science continues in a pandemic. Postcard from the Field, Eos, American Geophysical Union, August 11, 2020. https://americangeophysicalunion.tumblr.com/post/626169466882031616/lake-observing-science-continues-in-a-pandemic

Biddanda, B.A. 2020. On the 50th Earth day, a new course: ENS 310 – How the biosphere works. InterChange, May 2020. https://www.gvsu.edu/rmsc/interchange/2020-may-connections-biosphere-1591.htm

Biddanda, B. 2020. Top science story of 2019: now you see it – the first picture of a Black Hole. InterChange, February 2020. https://www.gvsu.edu/rmsc/interchange/2020-february-connections-black-holes-1543.htm

Biddanda, B. and **A. Weinke****. 2020. Abrupt continental ice loss and sea level rise. eLetter. Science, March 30, 2020. https://science.sciencemag.org/content/367/6484/1316/tab-e-letters

Newman, E.** 2020. Star Wars on Pentwater Lake. The Michigan Riparian, 55:4.

Stone, I.*, **J. Mancuso****, **N. Dugener****, **A. Weinke****, and **B. Biddanda**. 2020. Future choice – now! A book review of "The future we choose: surviving the climate crisis" by C. Figueres and T. Rivett-Carnac, 2020. InterChange, September 2020. https://www.gvsu.edu/rmsc/interchange/2020-september-connections-1601.htm

2020 Master of Science Theses

Allen, M. (Advisor: Rediske) Public and environmental health restoration of the Little Flower Creek watershed, Muskegon County, Michigan.

Harman, T. (Advisor: Strychar) Analysis of seasonal changes in thermal stress resilience and innate immunity in the temperate coral, *Astrangia poculata* (Ellis & Solander 1786), from future climate impacts.

Mancuso, J. (Advisor: Biddanda) Bloom or bust: Search for phytoplankton community drivers using long-term time-series observations and field measurements in a model Great Lakes estuary.

Photo Credit: Maggie Oudsema

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