2012 R.B. ANNIS WATER RESOURCES INSTITUTE Year in Review

The Mission of the Robert B. Annis Water Resources Institute (AWRI) at Grand Valley State University is to integrate education, outreach, and research to enhance and preserve freshwater resources. Located in Muskegon, Michigan, the Institute's work centers around three main focal areas:

Research into major questions about aquatic ecology, biogeochemistry, climatology, environmental chemistry and toxicology, fisheries biology, hydrology, limnology, microbial ecology, stream ecology, watershed ecology and management, and wetlands ecology.

Information Services uses 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.

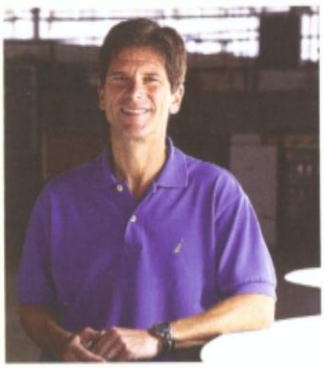
Photo Credit: Carl Ruetz

GRAND VALLEY STATE UNIVERSITY
ROBERT B. ANNIS WATER RESOURCES INSTITUTE

Table of Contents

Defining Success

Dr. Alan Steinman, Director



I arrived at the Annis Water Resources Institute in 2001, just as AWRI moved from the Allendale campus to the Muskegon lakeshore. GVSU had a vision to develop a world-class institute focused on freshwater resources, which sounds wonderful, assuming of course you are not the one responsible for making it happen! Actually, the process of our growth and maturation has been surprisingly smooth, and it can be attributed to three major factors: 1) the incredibly strong foundation left to us by our predecessors; 2) the support of Muskegon, and indeed, the entire west Michigan community; and 3) the hard work and dedication of the students, faculty, and staff at AWRI.

Collectively, these factors have helped us succeed in achieving our mission: to integrate research, education, and outreach to preserve and enhance freshwater resources. Of course, defining what is meant by success can be a tricky business.

As you read through AWRI's 2012 Year in Review, and learn about the Institute's remarkable accomplishments this past year, I hope that you will agree with me that we continue to achieve success, regardless of how it is defined.

Our research findings are being used locally (to restore Ruddiman Creek's flow regime), regionally (to improve our yellow perch and sturgeon fisheries), nationally (to better understand the death of coral reefs), and internationally (to provide potable water in Haiti). In addition, our vessel education program continues to provide a hands-on learning experience for thousands of students and adults each year. Our accomplishments have not gone without notice—the Discovery Channel featured AWRI's work on freshwaler research and education this past summer on their Profiles Series (see the video clips at http://www.gvsu.edu/wri/discovery).

And, finally, I would be remiss not to mention our new field station building. This facility will launch AWRI, GVSU, and the lakeshore far into the 21st century. We deeply appreciate the support of the community in this initiative, which is described in more detail on page 2. Thanks to your help and support, the completion of this field station will lead to better science, better collaboration, and better solutions—and surely, those are pretty good indicators of success.

Alan Steinman

New Robert B. Annis Water Resources Institute Field Station

In February 2012, the Grand Valley State University Board of Trustees approved the construction of a new field research building for the Annis Water Resources Institute. The new facility will be located on the site of the existing field station building, which was an unheated building previously used for boat repairs.

The $3.4 million project is made possible by a lead gift from an anonymous donor through the Community Foundation for Muskegon County, as well as by a combination of an existing federal grant, private donations, and university capital development funds. The Honorary Chair of the building campaign is Chuck Johnson II, with both Mike Olthoff and Larry Hines serving as Campaign Co-chairs. A huge thank you to all three of these community leaders for their support!

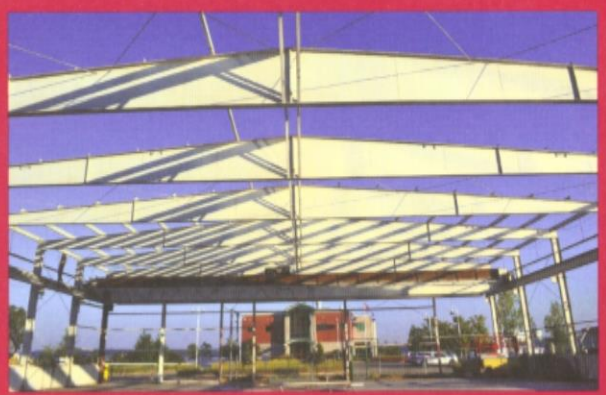
Demolition of the old building was completed during summer 2012; Great Lakes Dock & Marine donated their services to remove the old building, with the intention to repurpose it at their site on Muskegon Lake. We thank George Bailey and his crew for their efforts.

The new 14,800-square-foot building will meet the immediate and long-term needs of the Institute, and include state-of-the-art laboratories dedicated to studying the emerging issues facing Lake Michigan in the 21st century. Additional elements include a new aquatic tank facility to conduct controlled experiments, a boat loading bay, new researcher and graduate student offices, and secure storage. The building is being built to meet stringent LEED certification standards. Construction is slated for completion by June 2013.

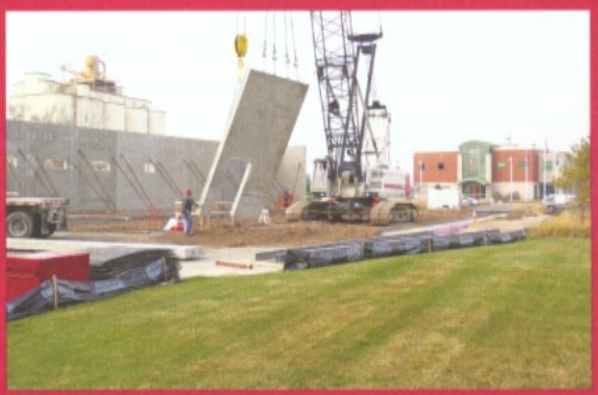
Please visit the new field station photo blog for construction updates: www.gvsu.edu/wri/photoblog

Giving opportunities can be found at www.gvsu.edu/giving/awri.

GREAT LAKES. GREAT PROMISE.



The steel frame of the old field station in front of the Lake Michigan Center.



Construction of the new field station in progress.

From Global to Local

what does climate change mean to you?

There is a lot of confusion between climate and weather, so... what is the difference? Climate is related to long-term averages, on the order of months, years, decades, centuries, etc. Weather is what you see every day, or what can be predicted from days to weeks. Scientists have suggested that climates have warmed by 1°F (0.6°C) worldwide and are predicted to increase another 2.5-10°F (1.4-5.8°C) by the end of the century. But what's the evidence? Perhaps the evidence is in Lake Superior where water temperatures have increased 12°F and winter ice has decreased from the 1950's. Further evidence might be the earlier growing seasons for our local food crops (e.g., cherries, apples, and peaches blossoming early).

AWRI's new climatologist, Kevin Strychar, will be exploring what global climate change means for communities located locally to globally. His studies have taken him to diverse areas that are experiencing the effects of climate change, including the deep waters of the Great Lakes, Hong Kong, and the Pacific island of Palau. The goal of his research is not only to help other peoples and nations understand the effects of climate change, but to bring that knowledge back home to help our Great Lakes communities. For example, with new invasive species, do we know what diseases they carry? As the temperatures warm in the Great Lakes, do we know how the temperature shifts will affect algal and bacterial blooms? And more importantly, what mechanisms do we have to fend off "diseases"? Strychar and his students are exploring these effects, but also looking for answers in organisms' natural immune systems. Some organisms have been here for millions of years, and knowing that, the big questions are what has allowed them to survive all of these years, what can we learn from them, and how can we use that knowledge to improve human health.

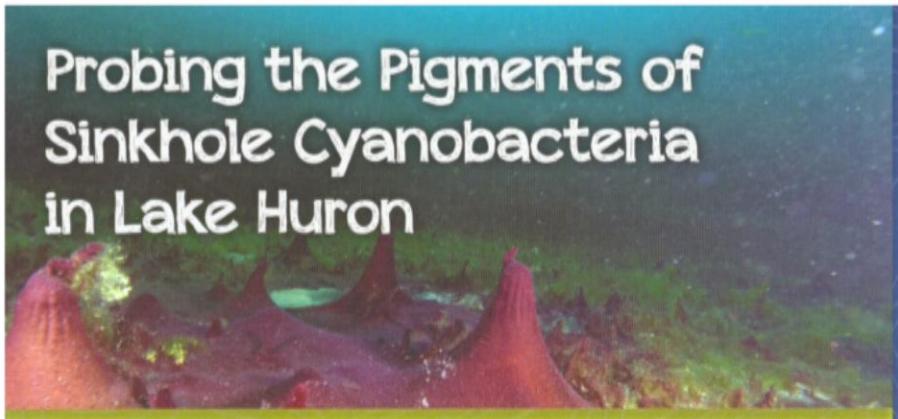
Strychar collaborates with scientists internationally, such as in Hong Kong (above), discussing environmental bioindicator organisms that are sensitive to heat stress.

AWRI/MSU graduate students Joshua Haslun (top) and Briana Hauff (bottom) diving in the Florida Keys. Joshua and Briana are studying the immunology of corals to better understand the effects of climate change and apply that knowledge to human health.

Welcome Dr. Strychar!

AWRI is pleased to welcome our new climatologist, Dr. Kevin Strychar. Kevin's expertise on the effects of climate change on freshwater and marine ecosystems is a valuable asset to AWRI and GVSU.

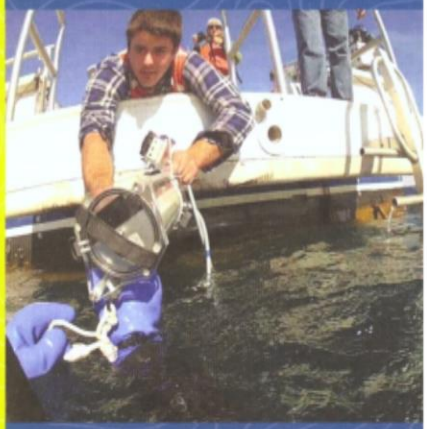
Probing the Pigments of Sinkhole Cyanobacteria in Lake Huron



The bottom of Lake Huron's Middle Island Sinkhole is characterized by purple cyanobacterial mats – some of which are raised into hills by microbial gasses generated within the sediment.

Time, water, and geologic forces have conspired to create underwater sinkholes where oxygen-poor and sulfur-rich groundwater fuel versatile microbial mats resembling life on early Earth's shallow seas nearly 3 billion years ago.

A seemingly alien environment of strange life exists in Michigan's own backyard – the Great Lakes. Here, in the depths of an offshore sinkhole near Middle Island in Lake Huron, a living purple carpet sprawls across the lake floor dotted by peculiar raised "fingers" made purely of microbial life reaching upwards like stalagmites. This rare ecosystem in Lake Huron is giving researchers a glimpse of what our planet and its life may have been like hundreds of millions of years ago during the Paleozoic era. During this period, microbes produced oxygen from photosynthesis that led to the initial oxygenation of Earth. AWRI graduate student Michael Snider is researching photosynthesis in this system for his Master's thesis, with Dr. Bopi Biddanda. He hopes to learn how these ancient microbial mats live 75 feet (23 meters) below the water surface, in an environment where elements like sulfur are more abundant than oxygen and light is scarce. He is measuring photosynthetic pigment concentration and photosynthetic efficiency in the bottom of the sinkhole and in laboratory-based experiments. These cyanobacteria utilize two distinct types of photosynthesis, one "ancient and non-oxygen-producing" and one "modern and oxygen-producing". Modern-day sinkhole ecosystems with cyanobacteria thriving in a low-oxygen, high-sulfur environment are a useful model for studying the evolution of photosynthesis on early Earth. Michael's work will help explain the inner workings of a relatively poorly understood microbial community, and may reveal the susceptibility of this ecosystem to ongoing anthropogenic changes in the Great Lakes. The many secrets of this novel ecosystem are only just beginning to be uncovered. Michael has received funding from the Michigan Space Grant Consortium, GVSU Presidential Award, and AWRI.



On board NOAA's *RV Storm*, graduate student Michael Snider hands a submersible fluorometer (Diving-PAM) to a NOAA diver over the sinkhole in Lake Huron.

Global warming is killing corals worldwide but what does that mean to you?

Climate change not only affects us here in Michigan, but is also having dire consequences worldwide. Take coral for example. These tiny animals restricted to growth in tropical climates are being decimated. Sensitive to temperature changes of only one degree, healthy corals are bleaching (turning white) and dying. But what does that mean to you?

Kevin Strychar and his graduate students study these animals as bioindicators, which are organisms used to predict environmental changes. His lab has found how some of these animals cope with heat stress, and in the process, have discovered applications that may be useful for human health. His lab has shown that some coral proteins have the ability to kill human prostate and breast cancer cells.

Despite being tiny, these animals and their algal counterparts are responsible for ~25% of world fisheries – and generate more oxygen than the Amazon rainforests. Their demise could spell trouble for global to local communities.

Plate coral (*Acropora palmata*), once the dominant coral species worldwide, is on the verge of extinction primarily due to the effects of global warming.

Duck Creek Watershed Management Plan Completed

AWRI began its work on the Duck Creek Watershed Management Plan in February 2010, when the Information Services Center (ISC) was asked by the Muskegon Conservation District (MCD) to gather water quality information about the watershed into a comprehensive planning document. MCD was motivated to get involved at the insistence of the small but tireless Duck Creek Watershed Assembly (DCWA). In fact, it is the work of DCWA volunteers that gave rise to concerns about the watershed, inspired the preparation of a proposal, and ultimately influenced the USEPA/MDEQ to give a grant award! It was with the guidance and support from the DCWA that the Management Plan was developed.

The Duck Creek watershed is less than 14,000 acres in land area. The watershed began as a home for the Ottawa Indians, saw the first European settlers in the late 1700's, and became a center for fur trading and lumbering soon thereafter. It was during this time that the watershed began to lose an estimated 1,170 acres of wetlands. In spite of the continuing changes, the watershed remains home to several rare species including Tall Green Milkweed, Cerulean Warbler, and Eastern Box Turtle. Today, the two most prominent features in the watershed are Duck Lake State Park and Michigan's Adventure amusement park.

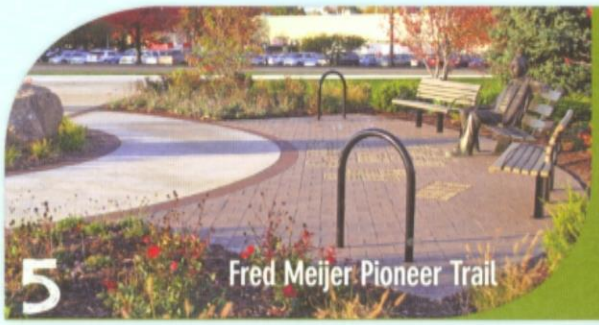
Although all waters in the Duck Creek watershed currently meet water quality goals, there remain concerns about the cold water fisheries due to increases in sedimentation, stream temperature, and pollutants like phosphorus, nitrogen, and bacteria. The plan outlines a course of action that protects the watershed through the rehabilitation of wetlands, stabilization of eroding streambanks, and elimination of pollutants. Thanks to the continued dedication of the DCWA, the watershed's future appears secure.

Social Vulnerability to Climate Change in West Michigan

People have been talking about climate change for more than twenty years. Most of this talk has dealt with global consequences of change using models intended to operate at the global scale. It hasn't been until recently that we have been able to consider the impact of future climate on local systems, such as watersheds. The focus for these discussions has also shifted as more scientists consider adaptation, or how society will change in response to future climate.

Wipperfurth intern Anna Daves, guided by Research Associate John Koches, is exploring the vulnerability of west Michigan residents to changing climate. Natural hazards, extreme heat, air quality, and infectious disease are likely to impact some members of our society more than others. Existing data sets make it possible to map vulnerability factors. Knowledge about this vulnerability should prove invaluable as we struggle with the need to balance social, economic, and environmental goals in the face of a changing climate.

"How are we going to adjust to changing climate?" asks student Anna Daves, 2012 recipient of the Bill and Diana Wipperfurth student research scholarship.



Fred Meijer Pioneer Trail

The Information Services Center (ISC) has recently completed a trail mapping project with the West Michigan Trails and Greenways Coalition. The trail maps are available for use on Apple mobile devices and are for sale at the Apple App Store. More information can be found online: http://www.wmtrails.org/Trail-Maps/Digital-Maps

Looking at the color of Lake Michigan near Holland

Lake Michigan Tour and Teacher Workshops Highlight Vessel Season

Through EPA's Great Lakes Restoration Inititative (GLRI) funding, both the *W.G. Jackson* and the *D.J. Angus* were able to offer a variety of programs in summer 2012. Our two-year grant included three partners (Inland Seas Education Association, MSU Sea Grant, and BaySail) who delivered onboard programs as well. In 2012, the *Jackson* and the *Angus* served six ports of call with GLRI cruises, open houses, and teacher workshops. The ports included Grand Haven, Holland, Ludington, and White Lake in Michigan and Manitowoc and Milwaukee in Wisconsin.

Some of the partners who helped make the events happen are Kae DonLevy (Lake Michigan Forum member in the Milwaukee area), Tanya Cabala (White Lake Public Advisory Council), Dr. Hamdy Helal (West Shore Community College near Ludington), Mason Lake Intermediate School District, Steve Bulthuis and Kelly Goward (Macatawa Area Coordinating Council in Holland), and Dr. Robert Cornwell in Manitowoc, Wisconsin.

Teacher workshops were held on the *Angus* in Grand Haven for the West Michigan Great Lakes Stewardship Initiative hub, the Groundswell Great Lakes Stewardship Initiative hub, and the Alliance for the Great Lakes. The Alliance's new *Great Lakes in My World 9-12* curriculum was launched at the workshop. The *Earth Partnership for Schools* curriculum was a focal point in the West Michigan Great Lakes Stewardship Initiative workshop. In Manitowoc, teachers participating in a week-long workshop hosted by the Wisconsin Department of Natural Resources enjoyed a cruise on the *Jackson*.

Exploring the sediment in Lake Macatawa

According to the project manager, Dr. Janet Vail, "AWRI is very pleased to receive GLRI funding for the project for an additional two years. We are already beginning to plan the activities for summer 2013 and 2014."

Where are they now? Outreach & Education Interns

The AWRI outreach and education program provides an opportunity for future teachers to get experience with a variety of different student groups, both in the R.B. Annis Educational Foundation Classroom and on the AWRI vessels, while receiving training in environmental education programs. Examples of some who have gone on to successful teaching positions are:

Brett Shelagowski was an AWRI intern when he was at Muskegon Community College (2000) and GVSU (2001). He now teaches high school in Montana.

Amanda Maycroft teaches 6th, 7th, and 8th grade environmental science at Krueger Middle School in Michigan City, Indiana. She was an AWRI intern in 2010.

Genetic "fingerprints" Help Answer Questions about Fish

Jesse (Comben) Wesolek extracts DNA from lake sturgeon samples for genetic analysis

AWRI scientists are collaborating on several research projects that use molecular population genetics to study fish dispersal and movement. Dr. Carl Ruetz has long been interested in studying movement patterns of fish, often using telemetry to track individuals in lakes and rivers. However, many important ecological questions regarding fish movement are difficult to study at large spatial scales and over long time intervals. Dr. Ryan Thum's expertise on population genetics provides a solution. Individual fish have genetic "fingerprints" that carry signatures of their historical and contemporary movement across generations. Together, Ruetz and Thum, along with AWRI graduate students, are applying genetic analyses to study important questions such as:

- How are diseases transmitted across the landscape in a native, bottom-dwelling fish called the mottled sculpin?
- How has the invasive round goby spread across Lake Michigan?
- How do native lake sturgeon—a threatened and iconic species—move among spawning rivers?
- Are yellow perch populations in Muskegon Lake and other drowned river mouth lakes reproductively isolated from Lake Michigan?

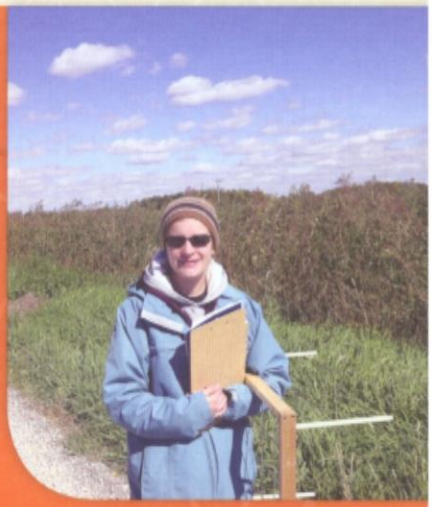
The results of these research projects will help government agencies make more informed decisions regarding the management of our important aquatic resources.

AWRI graduate student Syndell Parks is working with Dr. Ryan Thum on a collaborative research grant with Michigan State University. The research focuses on uncovering the molecular mechanism for herbicide resistance by invasive Eurasian watermilfoil in the Great Lakes.

Where are they now?

Elizabeth LaRue, AWRI Graduate Student

Liz LaRue earned her Master's degree from AWRI in 2012, studying the sensitivity of hybrid watermilfoils to herbicides with Dr. Ryan Thum. Liz is currently in the Biological Sciences, Ecology, and Evolution Ph.D. program at Purdue University. Her dissertation research is developing, but currently focuses on rapid adaption of wetland plants to climate change and the effect this has on ecological dynamics. Liz feels confident she will succeed in her Ph.D. program because of the many skills she acquired while earning her Master's degree at AWRI.



Liz LaRue doing field sampling for her Ph.D. project at Purdue University

Muskegon Lake:
A Nursery for Juvenile Lake Sturgeon

The lake sturgeon has been decimated throughout much of its native range and is now a threatened species in Michigan. Efforts are underway to restore lake sturgeon abundance throughout the Great Lakes basin. Dr. Carl Ruetz and his students at AWRI have studied lake sturgeon in the Muskegon River system since 2008, in collaboration with the Michigan Department of Natural Resources. One of the aims of the study is to understand the habitat use of juveniles in Muskegon Lake. The results of this research suggest that Muskegon Lake is an important nursery habitat for juvenile lake sturgeon after hatching in the Muskegon River. Juveniles appear to spend several years in Muskegon Lake before migrating to Lake Michigan, where they will spend upwards of a decade before returning to the Muskegon River to spawn as adults. Understanding the basic natural history of lake sturgeon is a critical component for successful restoration of the species.

Graduate student Brandon Harris with a lake sturgeon captured as part of a study assessing the distribution and population status of lake sturgeon in Muskegon Lake.

The Secret Lives of
Au Sable River Brown Trout

Where do Au Sable River brown trout live during the day? Night? Summer... winter? If a brown trout lives in one location during the summer, where does it spawn? Do patterns change between years? Unfortunately, trout keep their lives a big secret. Dr. Mark Luttenton hopes to change that by letting the fish provide some of the answers. With support from the Anglers of the Au Sable, and the Headwaters and Mason-Griffith Chapters of Trout Unlimited, Mark and his students implanted 34 brown trout with radio transmitters and began tracking them in July 2012. By following brown trout in the Au Sable River system for 22 months, they hope to learn about their daily, nightly, and seasonal movements, where they live, and why they choose those locations. And by the end, brown trout lives should be a little less of a secret.

The thin radio transmitter wire near this brown trout's pelvic fins allows researchers to follow its movements in the Au Sable River.

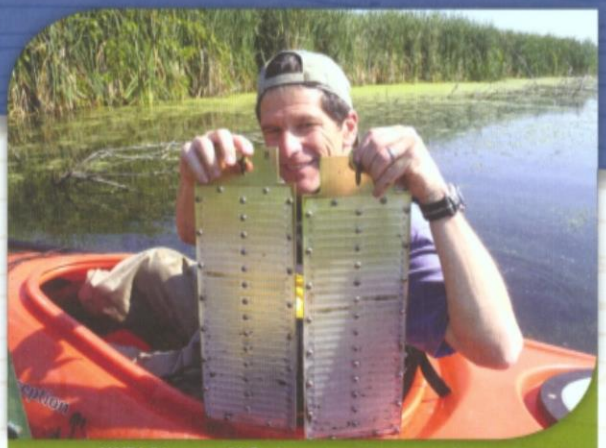
PCB Concentrations in
Lake Erie Burbot

AWRI researchers Dr. Richard Rediske and Jim O'Keefe are working with United States Geological Survey (USGS) scientists Charles Madenjian and Martin Stapanian to study the concentration of PCBs in male and female burbot from Lake Erie. Burbot is a freshwater species of cod and is classified as a top predator. Their diet has shifted from rainbow smelt to round goby and, consequently, there is an interest in examining contaminant levels. The results of the research were:

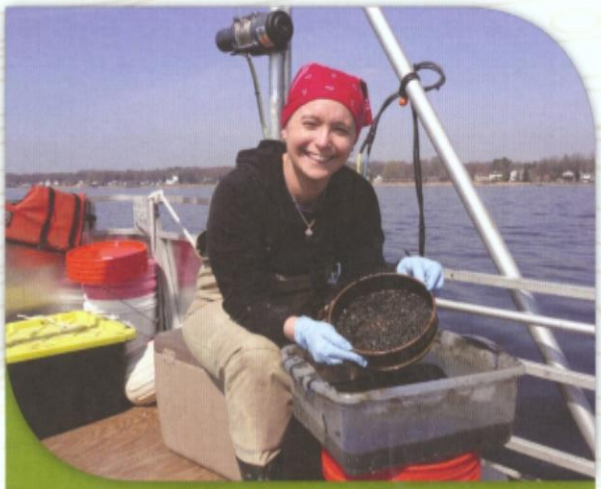
- For ages 6-13, males had 27% greater PCB concentrations than females.
- For ages 14-17, males had 71% greater PCB concentrations than females.
- Higher PCB levels in males were attributed to higher metabolic rates and habitat differences.

Undergraduate student Travis Bisson setting up Soxhlet Extractors for burbot analysis.

AWRI at work 2012



AWRI Director Al Steinman retrieving sediment pore water samplers ("peepers") from the muck fields adjacent to Bear Creek.



Post-doctoral researcher Géraldine Nogaro sieving sediment from Muskegon Lake to collect burrowing macroinvertebrates and study their influence on nutrient biogeochemistry in impacted lake ecosystems.

Robert B. Annis Foundation intern Anna Harris collecting water samples from sediment cores in the lab to study the effects of a phosphorus inactivation treatment (alum addition) on water quality.

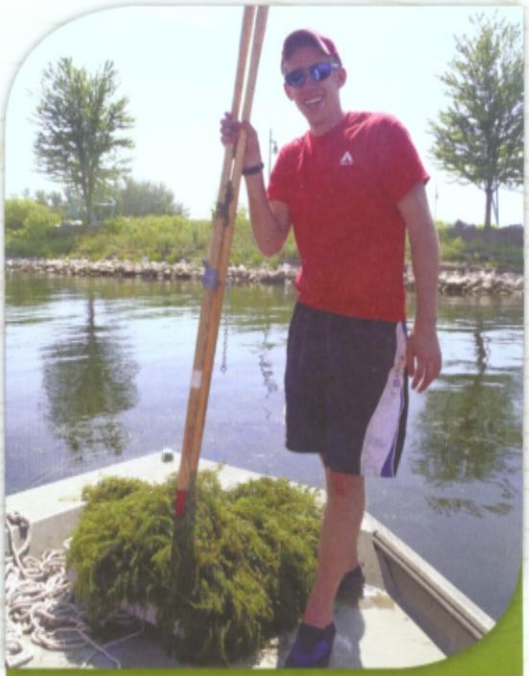
AWRI students Jessica (Comben) Wesolek, Brandon Harris, and Allison Kneisel remove a fyke net from Stony Lake to sample fish.

Dr. Mark Luttenton assisting Research Assistants Maggie Weinert (foreground) and Mary Ogdahl (background) with wetland plant identification on the edge of Muskegon Lake.

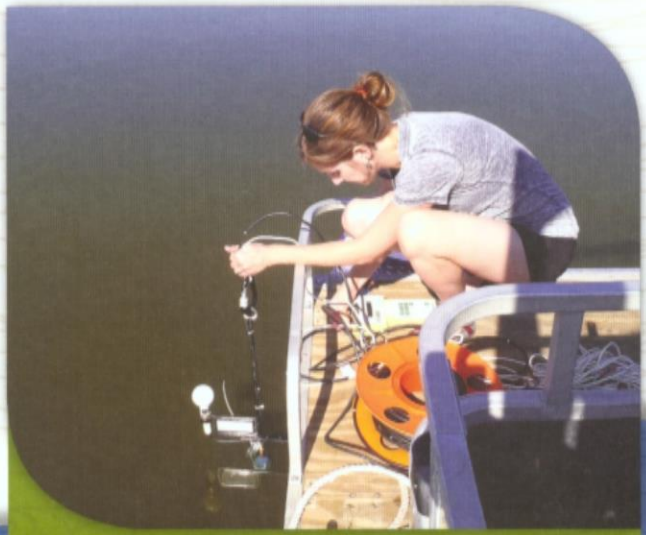
Dr. Bopi Biddanda and undergraduate student Anthony Weinke examine microbial mats collected from Lake Huron's submerged sinkholes.

Sara Damm, lab technician, assisting with measuring microbial activity on sediment samples to determine the effects of native and invasive species on the microbial community in Lake environments.

As an intern in the outreach and education program, Tara Eilers assisted in delivering education programs on the *W.G. Jackson* in Chicago, as well as at other ports of call in Lake Michigan.



Graduate student James Smit collecting macrophytes from Muskegon Lake to help assess the effects of shoreline restoration.



Research Assistant Mary Ogdahl measuring a light profile in Bear Lake before collecting sediment cores for estimation of internal phosphorus loading.

A "Diet Plan" for Ruddiman Creek

With funding from a Great Lakes Restoration Initiative grant, AWRI has been working with local stakeholders, U.S. Environmental Protection Agency (U.S. EPA), Michigan Department of Environmental Quality (MDEQ), Fishbeck, Thompson, Carr, & Huber, and the West Michigan Shoreline Regional Development Commission to identify pollutant reductions (i.e., a "diet plan") to help the highly urbanized Ruddiman Creek become healthier. Dr. Alan Steinman's lab monitored Ruddiman Creek and its contributing storm sewers for one year, during both dry weather and storms, to understand the urban system's altered hydrology and its impact on biota.

They discovered that the main problem is the vast amount of impervious surfaces in the watershed, such as parking lots, roads, rooftops, and storm sewers, which inhibit the natural infiltration of stormwater. As a consequence, large pulses of stormwater runoff enter the tributaries very quickly, causing erosion and streambed alterations that ultimately destroy habitat for sensitive stream-dwelling creatures. The project team determined that Ruddiman Creek would benefit from more stable hydrology, which could be accomplished through the use of best management practices (BMPs), such as rain gardens, green roofs, and porous pavement.

The information and recommendations generated by this project will be used by the MDEQ to develop a Total Maximum Daily Load (TMDL) for Ruddiman Creek. Because Ruddiman Creek does not meet Michigan water quality standards for macroinvertebrate communities (e.g., insects, snails, worms, etc.), the U.S. EPA requires it to have a TMDL for biota. The Ruddiman Creek TMDL will establish target reductions in impervious areas that would result in improved macroinvertebrate communities. For more information, please visit www.gvsu.edu/wri/director/ruddiman.

Water was sampled directly from storm sewers to characterize their influence on Ruddiman Creek.

A Total Maximum Daily Load, or TMDL:

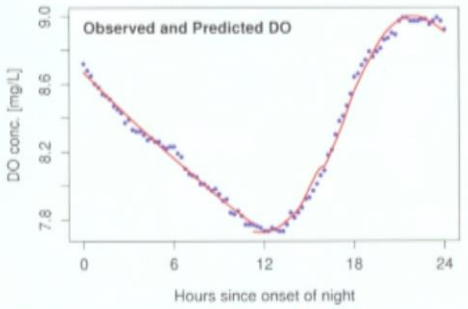
- **establishes the maximum amount of a pollutant allowed in a waterbody,**
- **allocates that load among all of its sources in the watershed,**
- **identifies the pollutant reductions necessary to restore and maintain water quality, and**
- **develops a suite of BMPs to help reach TMDL targets.**

Water levels rose dramatically during storm events in Ruddiman Creek. Sara Damm (left) and Mary Ogdahl (right) are shown sampling at the same location during dry weather and a storm, respectively.

New Statistical Methods for Estimating Components of Lake Metabolism

The global exchange of carbon (CO_2) and oxygen (O_2) between ecosystems and the atmosphere constitutes one of the largest mass movements of elements on Earth. It is driven primarily by the uptake of CO_2 and production of O_2 by photosynthesis (mainly by plants, algae, and photosynthetic bacteria) and by the uptake of O_2 and production of CO_2 by aerobic respiration (by most organisms on the planet). These two metabolic processes—photosynthesis and respiration—are among the most fundamental life processes in the biosphere, and the importance of accurately measuring their rates cannot be overemphasized.

The most common method of estimating rates of photosynthesis and respiration in lakes around the world uses high-frequency time series of dissolved oxygen (DO) concentrations that are measured by automated sensors deployed in lakes. Rates of photosynthetic O_2 production and respiratory O_2 consumption are estimated from changes in DO concentration.



Example of an observed time series of dissolved oxygen (DO) concentrations in Muskegon Lake (blue dots), together with the values predicted by one of the new statistical models developed by AWRI researchers (red line).

This traditional method employs a simple accounting procedure to estimate lake metabolism. But this method is not statistically rigorous, and relies on arbitrary assumptions for estimating respiration during daylight hours.

To resolve these problems, a team of AWRI researchers and graduate students, led by Drs. Jim McNair and Bopi Biddanda, has derived three new quasi-mechanistic statistical methods for estimating rates of photosynthetic production and respiration in lakes. They are evaluating and comparing these new methods with the traditional accounting method by applying them to monitoring data generated by AWRI's Muskegon Lake Buoy Observatory (www.gvsu.edu/buoy/).

Real-time Tracking of Ecosystem Changes in Muskegon Lake

Real-time data from the Muskegon Lake Observatory are being used by researchers, boaters, fishermen, and teachers in the classroom as an active-learning tool to teach the science of ecosystem change (www.gvsu.edu/buoy). In the photo, Observatory manager Scott Kendall (background) and AWRI graduate student Leon Gereaux (foreground) are servicing the buoy system and taking manual measurements for comparison with buoy data.

AWRI received a $15,000 grant from the Alcoa Foundation to provide hands-on science experiences on the *W.G. Jackson* for students in Whitehall and Montague. By the end of the grant period in 2013, over 500 3rd grade, 8th grade, and high school students from the White Lake area are projected to participate in either a sampling cruise or water festival.

Rick Rediske (dark blue shirt), Peter Wampler (2nd from right), and Azizur Molla (far right) conducting family ethnographic interviews in rural Haiti.

GVSU Researchers Travel to Rural Haiti to Study Household Water Quality

Richard Rediske (AWRI), Peter Wampler (Geology), and Azizur Molla (Anthropology) traveled to rural Haiti in May 2012 to study bacterial concentrations in household and source water, in addition to examining the cultural practices concerning sanitation and water of the indigenous people. The research was conducted with a GVSU Center for Scholarly and Creative Excellence grant that focused on an innovative approach using ethnographic tools, including personal interviews and focus groups, to understand the cultural factors that influence water resource use and quality. The project goal was to determine if a combination of empirical water quality and qualitative ethnographic data could provide sustainable strategies for addressing water resource problems in Haiti and other underdeveloped countries.

During their 2 week trip to the Artibonite Valley of Haiti, 60 interviews were conducted along with 6 focus groups. The interviews were conducted with a local interpreter and filmed for future analysis. In addition, over 100

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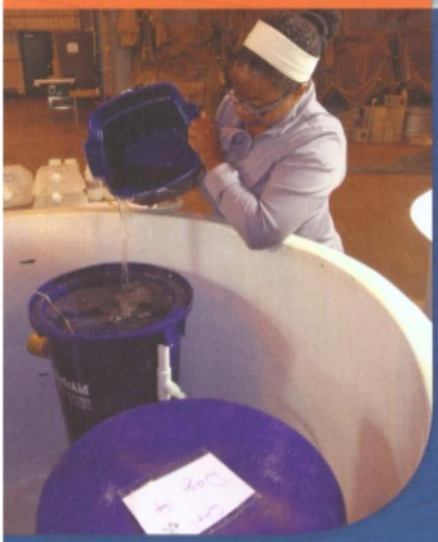


Graduate student Nicole Horne (left) filling a full-size biosand filter with Muskegon Lake water to test for its removal of microbes and toxins.

Getting Potable Water from Point-of-Use Biosand Filters

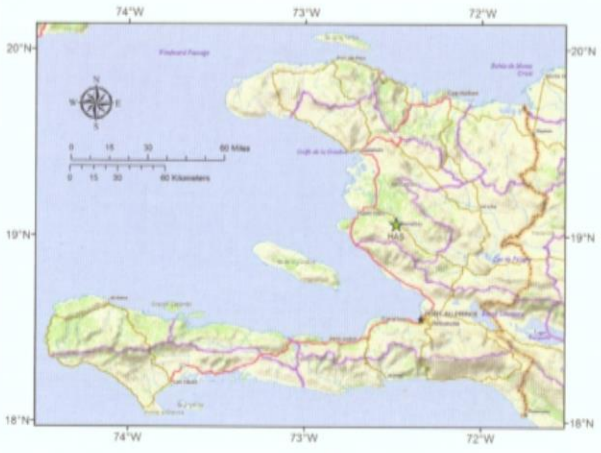
In many underdeveloped countries, taking a bucket to the local well or water source to get water is quite common. Contamination of these water sources has resulted in poor drinking water quality for over a billion people. An inexpensive remedy is the use of small biosand filters (BSFs) in households, classrooms, and hospitals to deliver safe potable water. Water poured into the BSF passes through sand which harbors a growing biofilm of beneficial microbes. AWRI graduate student Nicole Horne and Dr. Bopi Biddanda have investigated how well one particular BSF does in filtering harmful contaminants such as *Escherichia coli*, arsenic, and a toxin produced by a common bloom-forming cyanobacterium. Nicole found that the BSF removed most, and in some cases, all of the contaminants, demonstrating its potential to provide safer drinking water in regions where water-borne diseases and contaminants are of major concern.

The Nature Conservancy

Alan Steinman, director of Grand Valley's Annis Water Resources Institute, was selected to serve on the Board of Trustees of the Michigan Chapter of The Nature Conservancy (TNC). Al's initial appointment is for three years; he will be joining a Board whose current membership includes Gerry Anderson, CEO of DTE; Neil Hawkins, vice president for sustainability and environment at Dow Chemical; and Milt Rohwer, past president of the Frey Foundation. Previous Trustees included Rick Snyder, Governor of Michigan, and Mark Murray, president of Meijer.

samples of source and residential water were analyzed for *E. coli* bacteria, residual chlorine, and conductance. The research was performed in collaboration with Hôpital Albert Schweitzer (HAS) in Deschapelles. The preliminary results of the research include:

1. All families understood that microbes cause disease and the importance of treating their water.
2. Only 12% were still treating the water and 90% of this group were women with young children.
3. Six Biosand filter units were located and only 2 were functioning (98% pathogen removal efficiency).
4. Three Sawyer Filters were located and all were nonfunctional.
5. The failure of the filtration equipment was a result of improper training and/or lifestyle incompatibility.
6. Chlorinated and Biosand filtered water met U.S. standards.
7. Four households had drinking water that exceeded U.S. total coliform standards; the team was able to deliver chlorination supplies within 24 hours to the affected residences.



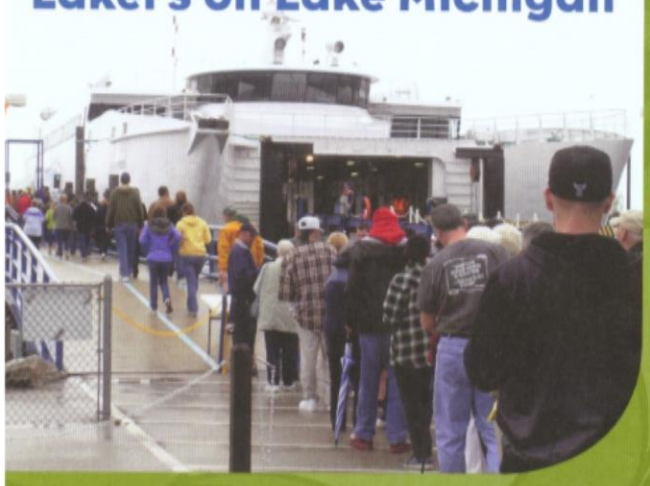
Map of Haiti and the study area. Hôpital Albert Schweitzer (HAS), marked with a star, collaborated with GVSU researchers on the project.

Recent AWRI Retirements

John Gort, a former science teacher, started at AWRI as deckhand in 1996 and later became a Science Instructor on the *W.G. Jackson*.

Ron Brown served as captain of the *W.G. Jackson* and the *D.J. Angus* as well as a deckhand. He joined AWRI in 2000 after a career at Amway Corporation.

Lakers on Lake Michigan



AWRI and the Lake Express hosted an open house event on May 5, 2012 to celebrate West Michigan's Blue Water Economy – a term used to describe businesses and initiatives that involve water resources. Hundreds of community members turned out to ride the Lake Express high-speed ferry and learn about AWRI's research projects. AWRI expresses its sincere gratitude to the Lake Express for donating proceeds from the event to AWRI's new field station building.

AWRI Faculty & Staff

Photo Credit: Janet Vail

Director:
Alan Steinman, Professor

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

Facilities/Maintenance:
Roger Hillstead, Maintenance

Information Services Center:
John Koches, Associate Research Scientist
- Rod Denning, Research Associate
- Betty Gajewski, Technical Call-in
- Jon VanderMolen, Technical Call-in

Outreach & Education:
Janet Vail, Associate Research Scientist
- John Bouwman, Science Instructor
- Paula Capizzi, Science Instructor
- Paul Carlson, Science Instructor
- Jake Dennison, High School Intern
- Leslie DeVries, Science Instructor
- Cheri Gerhart, Science Instructor
- John Gort, Science Instructor
- Samantha Gouine, High School Intern
- Shirley McIntire, Science Instructor
- Michele Smith, Science Instructor
- Amanda Syers, Technical Call-in
- Diane Veneklasen, Science Instructor

GVSU Vessels/ Field Station Operations:
Anthony Fiore, Jr., Fleet Captain
- Ronald Brown, Captain *WGJ*
- Dave Fisher, Marine Engineer *WGJ*
- Kevin Fitch, Captain *DJA*
- Cody Gillette, Deckhand *DJA* and *WGJ*
- Robert Marx, Deckhand *WGJ*
- Brad Nieboer, Marine Electrician
- Robert Pennell, Deckhand *DJA*
- Jim Rahe, Deckhand *WGJ*
- Mark Rose, Deckhand *WGJ*
- George Thibault, Deckhand *DJA*
- Russell Weeks, Deckhand *DJA*

Ecological Research, Environmental Chemistry:
Richard Rediske, Professor
- Jim O'Keefe, Research Associate
- Brian Scull, Research Assistant
- Whitney Nelson, Technical Call-in

Ecological Research, Environmental Biology:
Bopaiah Biddanda, Associate Professor
- Scott Kendall, Adjunct Research Assistant
- Tom Holcomb, Technical Call-in

Mark Luttenton, Professor of Biology
- Michael Vredevoogd, Technical Call-in
- Zak Wolcott, Technical Call-in

Jim McNair, Associate Professor

Carl Ruetz III, Associate Professor
- Jacob Boone, Technical Call-in
- Amanda Chambers, Technical Call-in
- Dave Janetski, Post-doctoral Researcher
- Stacy Provo, Technical Call-in

Alan Steinman, Professor
- Nadia Gillett, Post-doctoral Researcher
- Geraldine Nogaro, Post-doctoral Researcher
- Sara Damm, Technical Call-in
- Mary Ogdahl, Research Assistant
- Kurt Thompson, Research Associate
- Maggie Weinert, Adjunct Research Assistant

Kevin Strychar, Associate Professor
- Josh Haslun, Technical Call-in
- Briana Hauff, Technical Call-in

Ryan Thum, Assistant Professor
- Jeremy Newton, Technical Call-in
- Dustin Wcisel, Adjunct Research Assistant

Photo Credit: Janet Vail

Graduate Students:

Nicholas Albrecht, AWRI Assistantship (major advisor: Mark Luttenton)
Deb Dila, AWRI Assistantship (major advisor: Bopi Biddanda)
Travis Foster (major advisor: Mark Luttenton)
Leon Gereaux, AWRI Assistantship (major advisor: Bopi Biddanda)
Bryan Giordano, AWRI Assistantship (major advisor: Mark Luttenton)
Brandon Harris, AWRI Assistantship (major advisor: Carl Ruetz)
Jared Homola, AWRI Assistantship (major advisor: Carl Ruetz)
Nicole Horne, AWRI Assistantship (major advisor: Bopi Biddanda)
Elizabeth LaRue, AWRI Assistantship (major advisor: Ryan Thum)
Syndell Parks, AWRI Assistantship (major advisor: Ryan Thum)
Meagan Sesselman, AWRI Assistantship (major advisor: Jim McNair)
Andrew Sisson, AWRI Assistantship (major advisor: Rick Rediske)
James Smit, AWRI Assistantship (major advisor: Alan Steinman)
Michael Snider, AWRI Assistantship (major advisor: Bopi Biddanda)
Neal Swanson (major advisor: Mark Luttenton)
Jessica (Comben) Wesolek, AWRI Assistantship (major advisor: Carl Ruetz)
Alex Wieten, AWRI Assistantship (major advisor: Carl Ruetz)

Student Assistants:

Travis Bisson
Adrienne Gibson
Elizabeth Mullins
Andrew Pyman (volunteer)
Ben Sikkenga
Anthony Weinke
Michael Bredeweg
Allison Kneisel
Jeff Pashnick
Latricia Rozeboom
Lauren Villalobos (volunteer)

AWRI Science Advisory Board

Harvey Bootsma, Great Lakes WATER Institute, U of Wisconsin-Milwaukee
Carol Johnston, South Dakota State University
Gary Lamberti, University of Notre Dame; Chair
Don Scavia, University of Michigan

Internships & Scholarships

AWRI provides opportunities for students to pursue their interests in our environment. The following students received internships during 2012.

D. J. Angus-Scientech Educational Foundation Interns:

Shaughn Barnett
Alex Ebenstein
Tara Eilers
Terry Felty

Herbert VanderMey Intern:

Heather Snyder

Robert B. Annis Foundation Interns:

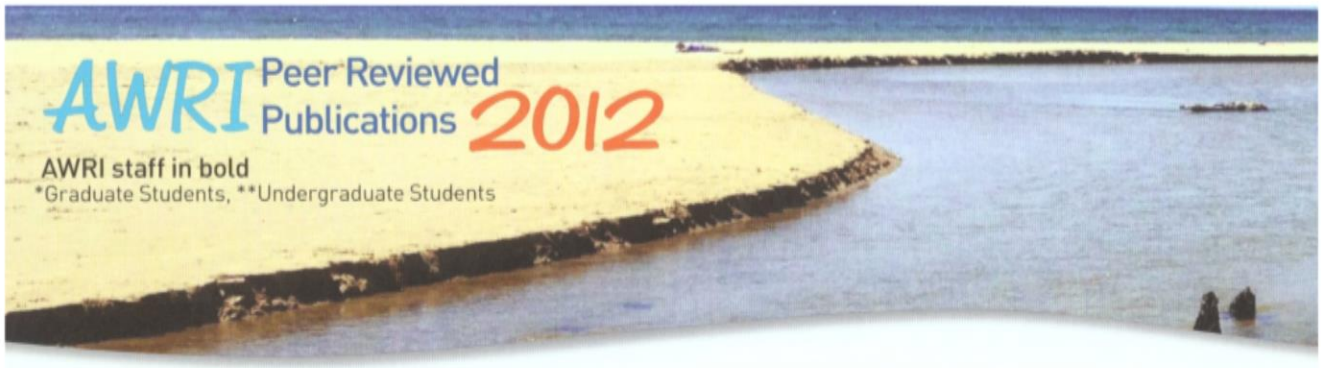
Youssef Darwich
Anna Harris
Elizabeth Sommers

Bill and Diana Wipperfurth Scholarship:

Anna Daves

Summer Student Scholar:

Danielle Grimm



AWRI Peer Reviewed Publications 2012

AWRI staff in bold
*Graduate Students, **Undergraduate Students

Allan, J.D. et al. (22 authors including **A.D. Steinman**). In Press. Joint analysis of stressors and ecosystem services to enhance restoration effectiveness. Proceedings of the National Academy of Sciences.

Allen, M.R., **R.A. Thum**, J.N. VanDyke, and C.E. Caceres. 2012. Trait sorting in *Daphnia* colonizing man-made lakes. Freshwater Biology 57(9): 1813-1822. DOI:10/1111/j.1365-2427.2012.02840.x

Biddanda, B., S. Nold, G. Dick, **S. Kendall**, **J. Vail**, S. Ruberg and C. Green. 2012. Rock, water, microbes: underwater sinkholes in Lake Huron are habitats for ancient microbial life. Nature Education Knowledge 3 (10):13. http://www.nature.com/scitable/knowledge/library/rock-water-microbes-underwater-sinkholes-in-lake-25851285

Cervino, J.M., **B. Hauff***, **J.A. Haslun***, K. Winiarski-Cervino, M. Cavazos, P. Lawther, A.M. Wier, K. Hughen, and **K.B. Strychar**. In Press. Ulcerated Yellow Spot Syndrome: implications of aquaculture-related pathogens associated with soft coral *Sarcophyton ehrenbergi* tissue lesions. Diseases of Aquatic Organisms. DOI: 10.3354/dao02541.

Chu, X. and **R. Rediske**. 2012. Modeling metal and sediment transport in a stream-wetland system. Journal of Environmental Engineering 137: 152-163. DOI: 10.1061/(ASCE)EE.1943-7870.0000472.

Cooper, M.J.*, **A.D. Steinman**, and D.G. Uzarski. In Press. Influence of geomorphic setting on the metabolism of Lake Huron fringing wetlands. Limnology & Oceanography.

Haslun, J.A.*, E. Correia, **K.B. Strychar**, T. Morris, and T.M. Samocha. 2012. Characterization of bioflocs in a no water exchange super-intensive system for the production of food size Pacific White Shrimp *Litopenaeus vannamei*. International Journal of Aquaculture 2: 29-39. DOI: 10.5376/ija.2012.02.0006

Homola, J.J.*, K.T. Scribner, R.F. Elliott, M.C. Donofrio, J. Kanefsky, K.M. Smith, and **J.N. McNair**. 2012. Genetically derived estimates of contemporary natural straying rates and historical gene flow among Lake Michigan lake sturgeon populations. Transactions of the American Fisheries Society 141: 1374-1388. DOI: 10.1080/00028487.2012.694829

LaRue, E.A.*, **M.P. Zuellig***, M.D. Netherland, M.A. Heilman, and **R.A. Thum**. In Press. Hybrid watermilfoil lineages are more invasive and less sensitive to a commonly used herbicide than their exotic parent (Eurasian watermilfoil). Evolutionary Applications.

MacDonald, N.W., D.W. Mays, **R.R. Rediske**, and **C.R. Ruetz III**. 2011. Environmental variation, fish community composition, and brown trout survival in the Pigeon River, Ottawa County, Michigan. Michigan Academician 40: 135-168.

McNair, J.N., A. Sunkara, and D. Frobish. 2012. How to analyze seed germination data using statistical time-to-event analysis: nonparametric and semiparametric methods. Seed Science Research 22: 77-95. DOI: 10.1017/S0960258511000547

McNair, J.N., A. Sunkara, and D. Frobish. 2012. Supplementary material: how to analyze seed germination data using statistical time-to-event analysis: nonparametric and semiparametric methods. Seed Science Research. Available online.

McNair, J.N. and J.D. Newbold. 2012. Turbulent particle transport in streams: can exponential settling be reconciled with fluid mechanics? Journal of Theoretical Biology 300: 62-80. DOI: 10:1016/j.jtbi.2012.01.016.

Nelson, W.* and **A.D. Steinman**. In Press. Changing trends in benthic communities in a coastal drowned river mouth lake, a Great Lakes Area of Concern. Journal of Great Lakes Research.

AWRI Technical Reports/ Manuals and Non-Peer Reviewed 2012

Allan, D. et al. (21 authors including **A.D. Steinman**). 2012. Science strategy for improving Great Lakes restoration: a document from Directors of U.S. and Canadian Great Lakes Academic Centers and Initiatives in response to the U.S. EPA Science Advisory Board Report, Great Lakes Restoration Initiative Action Plan Review (Jan.2012). Submitted to GLRI Regional Working Science sub-group.

Biddanda, B. Connections for the STEM Classroom: underwater sinkholes in Lake Huron are refugia for microbial ecosystems that are analogs to life on early Earth. Interchange, Vol. 19:6. http://gvsu.edu/rmsc/interchange/connections-for-the-K-12-classroom-299.htm

Biddanda, B. Lake Sentinel: observatory for ecosystem changes in Muskegon Lake. Interchange, Vol. 19, No. 4. http://gvsu.edu/rmsc/interchange/2012-may-science-and-math-update-651.htm

17 AWRI staff in bold
*Graduate Students, **Undergraduate Students

Photo Credit:
Sara Damm

Parker, A.P.*, M.J. Cooper, **C.R. Ruetz III**, D.P. Coulter, and D.G. Uzarski. 2012. Chemical and physical factors associated with yellow perch abundance in Great Lakes coastal wetlands: patterns within and among wetland types. Wetlands Ecology & Management 20: 137-150.

Poovey, A.G., C.R. Mudge, **R.A. Thum**, C. James, and K.D. Getsinger. 2012. Evaluations of contact aquatic herbicides for controlling two populations of submersed flowering rush. Journal of Aquatic Plant Management 50: 48-53.

Ruetz, C.R., III. 2012. Poster and oral presentations at professional meetings. In: Scientific communication for natural resources professionals. Pages 143-153. Editors: C.A. Jennings, T.E. Lauer, and B. Vondracek. American Fisheries Society, Bethesda, Maryland.

Ruetz, C.R., III, M.R. Reneski**, and D.G. Uzarski. 2012. Round goby predation on *Dreissena* in coastal areas of eastern Lake Michigan. Journal of Freshwater Ecology 27: 171-184.

Sabourin D.T., J. E.Silliman, and **K.B. Strychar**. In Press. Polycyclic aromatic hydrocarbon contents of coral and surface sediments off the South Texas Coast of the Gulf of Mexico. International Journal of Biology.

Sammarco, P.W. and **K.B. Strychar**. In Press. Responses to high seawater temperatures in Great Barrier Reef Octocorals: taxonomic implications. PLOS ONE. Manuscript ID: PONE-D-24588R1.

Sisson, A.*, P. Wampler, **R. Rediske**, and A. Molla. In Press. An assessment of long term Biosand Filter use and sustainability in Haiti. Journal of Water, Sanitation and Hygiene for Development.

Steinman, A.D., **M.E. Ogdahl**, **M. Weinert**, **K. Thompson**, M.J. Cooper, and D.G. Uzarski. 2012. Water level fluctuation and sediment-water nutrient exchange in Great Lakes coastal wetlands. Journal of Great Lakes Research 38: 766-775. DOI: 10/1016/j.jglr.2012.09.020

Steinman, A.D. and **M.E. Ogdahl**. 2012. Macroinvertebrate response and internal phosphorus loading in a Michigan lake after alum treatment. Journal of Environmental Quality 41: 1540-1548. DOI: 10/2134/jeq.2011.0476

Tavalire, H.F.*, G.E. Bugbee, **E.A. LaRue***, and **R.A. Thum**. In Press, available online. Hybridization, cryptic diversity, and invasiveness in introduced variable-leaf watermilfoil. Evolutionary Applications. DOI: 10/1111/j.1752-4571.2012.00267.x

Thum, R., **D. Wcisel**, **M. Zuellig***, M. Heilman, P. Hausler, P. Tyning, L. Huberty, and M.D. Netherland. In Press. Field documentation of decreased herbicide response by a hybrid watermilfoil population. Journal of Aquatic Plant Management.

Thum, R.A., **A.T. Mercer****, and **D. Wcisel**. 2012. Loopholes in the regulation of invasive species: genetic identifications identify mislabeling of prohibited aquarium plants. Biological Invasions 14: 929-937. DOI:10.1007/s10530-011-0130-8

Voorhies, A.A., **B. Biddanda**, **S. Kendall**, S. Jain, D. Marcus, S. Nold, N. Sheldon and G. Dick. 2012. Cyanobacterial life at low O_2: community genomics and function reveal high metabolic versatility and extremely low diversity in a Great Lakes sinkhole mat. Geobiology 10: 250-267. DOI: 10.1111/j.1472-4669.2012.00322.x

Xie, L., **R.R. Rediske**, **Y. Hong**, **J. O'Keefe**, **N. D. Gillett**, J. Dyble, and **A.D. Steinman**. 2012. The role of environmental parameters in the structure of phytoplankton assemblages and cyanobacteria toxins in two hypereutrophic lakes. Hydrobiologia 691: 255-268.

Zuellig, M.* and **R.A. Thum**. 2012. Multiple introductions of invasive Eurasian watermilfoil and recurrent hybridization with northern watermilfoil in North America. Journal of Aquatic Plant Management 50: 1-18.

Denning, R. 2012. Riparian Corridor Project – Crockery Creek Watershed. MR-2012-1.

Koches J., **R. Denning**, **A. Ebenstein****, **E. Arndt****, **J. VanderMolen**, and **N. DeMol.** 2012. Duck Creek Watershed management plan. MR-2012-2.

Ogdahl, M.E. and **A.D. Steinman**. 2012. Muskegon Lake Area of Concern habitat restoration project: macrophyte assessment. Submitted to the National Oceanic and Atmospheric Administration (NOAA).

Steinman, A.D., **M. Luttenton**, and **M. Ogdahl.** 2012. Monitoring of phytoplankton in Muskegon Lake: toward de-listing the eutrophication beneficial use impairment in a Great Lakes Area of Concern. Submitted to Consumers Energy Foundation.

Vail, J. 2012. Research Vessel *D.J. Angus* Use Report 2011. CR-2012-1.

Vail, J. 2012. Research Vessel *W.G. Jackson* Use Report 2011. CR-2012-2.

More About AWRI

If you would like more information about AWRI's programs, please contact us.

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Grand Valley State University
Robert B. Annis Water Resources Institute

R. B. Annis Water Resources Institute
Lake Michigan Center
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Photo Credit: Maggie Weinert

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