R. B. Annis Water Resources Institute 2014 YEAR IN REVIEW

The Mission

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

Research into major questions about aquatic ecology, chemistry and toxicology, fisheries ecology, hydrology, microbial ecology, aquatic molecular ecology, ecosystem restoration, and ecological modeling.

Information Services 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: Brian Scull

Grand Valley State University
Robert B. Annis Water Resources Institute

TABLE OF CONTENTS

FINDING SOLUTIONS

Dr. Alan Steinman, Director

Last year in this space, I reflected not only on AWRI's successes in 2013, but also noted that thanks to our numerous and generous partners, we remain committed to generating better science, better collaboration, and better solutions to protect and preserve water, our most precious natural resource. These commitments remain as firm as bedrock at the Annis Water Resources Institute.

As you read the stories in our 2014 Year in Review, there is a unifying thread that stitches our work together – the focus on solutions to our water resource challenges. While we will continue to pursue basic knowledge, we recognize that our research does not exist in a vacuum and that we must focus our intellectual capital on outcomes that have a bearing on the ecological health and integrity of our aquatic ecosystems.

The work at AWRI is helping identify the most appropriate restoration design for the Muskegon River, Lake Macatawa, and Bear Lake watersheds, among others. We are also investigating the sources of pollutants in the Lower Grand River watershed, which will help determine what best management practices to implement and where to place them. We also are focused on how to improve fish habitat and understand what influences the growth of key species such as brown trout, sculpin, yellow perch, and lake sturgeon. Our research also has human health implications, as we examine the anti-cancer properties of aquatic fungi in the Great Lakes. Even our basic research activities, such as better understanding lake metabolism and examining the photosynthetic behavior of cyanobacteria (blue-green algae) have societal implications; the metabolism work has led to insights into what controls low-oxygen zones (i.e., the inappropriately but provocatively termed "dead zones") in Muskegon Lake which, in turn, affect fish movement and behavior, whereas the cyanobacterial work may have implications for how life began on this planet. Pretty cool stuff.

Photo Credit: Brian Scull

FOREST STEWARDSHIP PLANS PROMOTE SUSTAINABLE PRACTICES

Jack Gibson, 2014 R.B. Annis Foundation intern, stands in the midst of a mature beech/maple forest inventoried as part of a forest stewardship plan.

Over the past year, we have been working with a number of private landowners, covering more than 900 acres in the Muskegon River watershed, to help them understand the unique natural character of their properties. "We've worked in a dry sand prairie, lowland and floodplain forests, areas dominated by black walnut trees, northern hardwood forest, and forested areas approaching 'old growth' conditions," says Rod Denning, Project Manager in the Information Services Center.

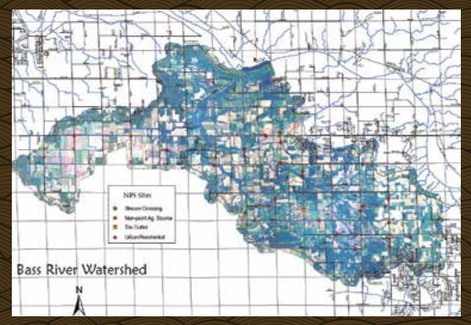
"We are often surprised by what we find, and the landowners are always eager to learn more about how they can become better stewards of the properties they hold."

A typical Forest Stewardship Plan includes an inventory of general characteristics: soils, current forest health, the type of forests present, type of wetlands present, and threatened/endangered species.

Denning says, "The overriding intent of a Plan is to help the landowners get a feel for what they have, what its condition is, and what they can do to make improvements. Ultimately, we hope that the landowners are encouraged to manage the land sustainably, and that forests remain forests for generations to come."

ONCE WE UNDERSTAND WHAT IS SPECIAL ABOUT THE PROPERTY, WE CAN THEN IDENTIFY AND RECOMMEND ACTIVITIES THAT WILL ENHANCE AND IMPROVE ITS MANAGEMENT.

MOVING BMP IMPLEMENTATION FORWARD



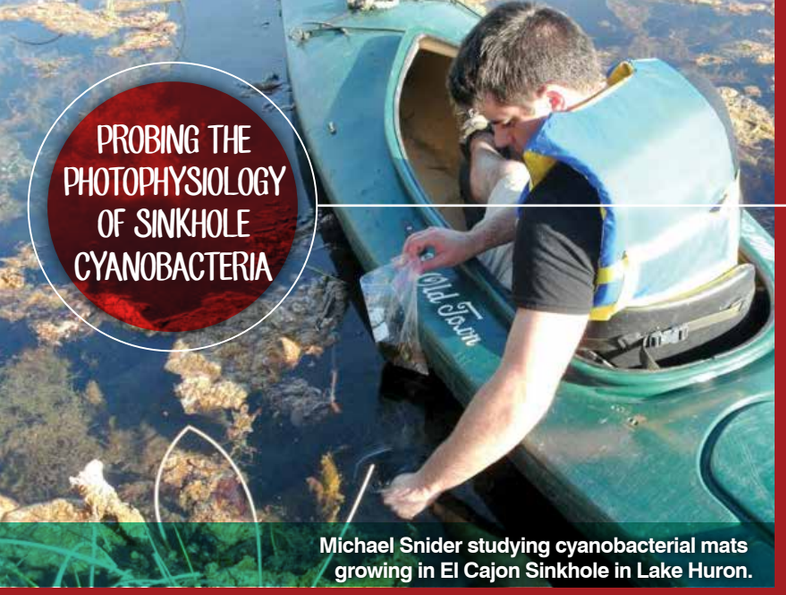
A map of different non-point source (NPS) pollutant inputs in the Bass River watershed.

Two map atlases produced for the Ottawa Conservation District will be used to aid in Best Management Practice (BMP) implementation for the Bass River/Deer Creek Restoration Project. The maps described human population distribution, land use and cover, *E. coli* sampling locations, and in the case of Bass River, the likely sources for nutrients and bacteria.

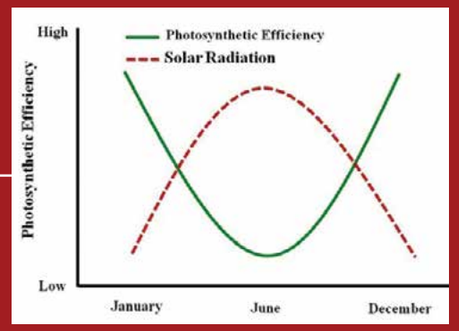
CLIMATE RESILIENCY AND WATERSHED MANAGEMENT

AWRI is wrapping up a three-year project with the Muskegon River Watershed Assembly to develop a Watershed Management Plan for the Upper Muskegon River watershed. This plan is unique as it is the first AWRI-produced management plan to explicitly consider global climate change. Expected increases in water temperature have obvious implications for aquatic life, but perhaps even more important is the expected change in hydrology. "Fortunately," says John Koches, Associate Research Scientist, "the solutions for many hydrologic issues are already well understood and involve using proven Best Management Practices, such as green infrastructure and low-impact development.

PROBING THE PHOTOPHYSIOLOGY OF SINKHOLE CYANOBACTERIA



Michael Snider studying cyanobacterial mats growing in El Cajon Sinkhole in Lake Huron.



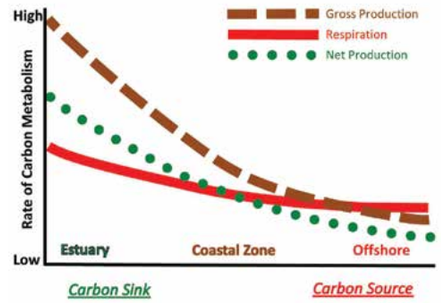
Overall photosynthetic health (defined here as photosynthetic efficiency) was found to vary seasonally and to be inversely proportional to solar radiation.

Michael Snider completed his master's thesis in the Biddanda Lab studying submerged sinkhole ecosystems in Lake Huron. Microbial communities in these high sulfide/low oxygen sinkholes are believed to be remnants of life that began oxygenating the planet almost 3 billion years ago. These modern-day cyanobacteria (blue-green algae) can conduct 'ancient' non-oxygen-evolving photosynthesis, as well as 'modern' oxygen-evolving photosynthesis. Michael studied the photophysiology and photosynthetic pigments of the cyanobacteria in field and laboratory studies. He found that 1) the cyanobacteria alter their pigment levels in response to seasonal changes in light and 2) that photosynthetic efficiency also follows a distinct seasonal trend. Lab studies characterized the effect of sulfide – a chemical that typically inhibits photosynthesis – and found that sinkhole cyanobacteria were capable of oxygen-evolving photosynthesis despite the presence of sulfide.

Another experiment showed that cyanobacterial motility via gliding filaments likely plays an important role in optimizing light capture. Forthcoming work will seek to identify the genetic relatedness of the different cyanobacterial communities and help answer questions about their evolution and versatility – and advance our understanding of the very first oxygenation events in the biosphere, modern-day photosynthesis, and the exploration of life on Earth and beyond.

Chasing Carbon

The carbon cycle of coastal ecosystems is a highly dynamic component of the global carbon cycle. Our decade-long study in the Muskegon Lake-Lake Michigan coastal ecosystem has revealed that carbon metabolism decreases along a land-to-lake gradient, with nearshore waters functioning as CO_2 sinks and offshore waters as CO_2 sources (Weinke & others 2014). Knowing how major ecosystem processes change across the coastal gradient will enhance our ability to predict future changes in such critically important land-margin ecosystems.

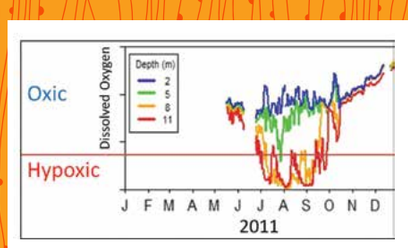


Conceptual diagram of carbon metabolism (gross production, respiration, and net production) along a land-to-lake gradient, showing an overall decrease in carbon metabolism from nearshore (i.e., estuary) to offshore waters (Weinke & others 2014). Areas of high carbon metabolism (i.e., estuaries) are carbon sinks, whereas areas of low carbon metabolism (i.e., offshore) are carbon sources.

CHRONICLES OF HYPOXIA

Instances of low dissolved oxygen concentration (hypoxia) in the bottom waters of Muskegon Lake have been previously documented during seasonal monitoring. However, the establishment of the Muskegon Lake Buoy Observatory, which contains many physical, chemical, and biological sensors throughout the water column, has shed new light on both the annual recurrence and temporal extent of hypoxia in Muskegon Lake. The observatory (www.gvsu.edu/buoy) has chronicled hypoxia in all four years of its operation since 2011. Bottom waters have experienced widespread hypoxia for well over a month every year, which has negative consequences for the lake's health, as many of its inhabitants rely on dissolved oxygen to survive.

Time-series dissolved oxygen data recorded from the buoy in 2011, showing hypoxic conditions at the 8 and 11 m depths from July through September.



MODELING THE EVOLUTION OF HERBICIDE RESISTANCE IN EURASIAN WATERMILFOIL

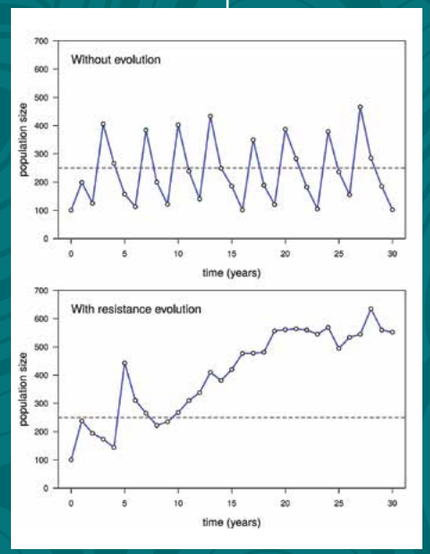
Millions of dollars are spent annually on herbicidal control of aquatic invasive plants in Michigan. Much of this expenditure is focused on Eurasian watermilfoil, a highly invasive plant native to Eurasia and northern Africa.

Genetic studies have shown that Eurasian watermilfoil hybridizes with northern watermilfoil, a species native to this region. Genetic analyses by Dr. Ryan Thum and his lab have resulted in the identification of more than 50 distinct hybrids between these invasive and native species. This work has shown that nuisance growths of "Eurasian watermilfoil" often are actually Eurasian-northern hybrids, which cannot be distinguished reliably from either parental species based simply on morphology.

AWRI scientists have shown that some of these hybrids have much greater resistance to common herbicides than do the parental species and also grow much faster. But do these properties explain the observed invasiveness? What is their genetic basis? And what are their implications for lake management?

To help answer these questions, Dr. Jim McNair is developing a realistic computer simulation model of watermilfoil populations that incorporates ecological, genetic, and management components. It will permit us to assess alternative management strategies to determine their likely long-term effects on watermilfoil abundance, including their potential role in the rapid evolution of herbicide resistance that commonly occurs in agricultural weeds.

(right) Predicted dynamics of Eurasian watermilfoil in a managed lake, without evolution (top) and with evolution of herbicide resistance (bottom). In this example, herbicide is applied when watermilfoil abundance exceeds 250 (arbitrary units), as indicated by the dashed horizontal line. Rapid evolution causes the watermilfoil population to become unresponsive to the herbicide and grow in population size. (bottom)



CONGRATULATIONS, LINDSEY!

Lindsey Schulte collecting watermilfoil on Houghton Lake as part of her thesis research.

Photo Credit: Paul Haulser, Progressive AE

Graduate student Lindsey Schulte and her advisor and co-author Dr. Ryan Thum received two first place awards this year in student paper presentation competitions. Lindsey's presentations at annual meetings of the Midwest Aquatic Plant Management Society and the National Aquatic Plant Management Society conveyed the results of her thesis research on herbicide resistance in hybrid watermilfoil.

INVASIVE CORAL IN THE GULF OF MEXICO

Oil platform in the Gulf of Mexico.

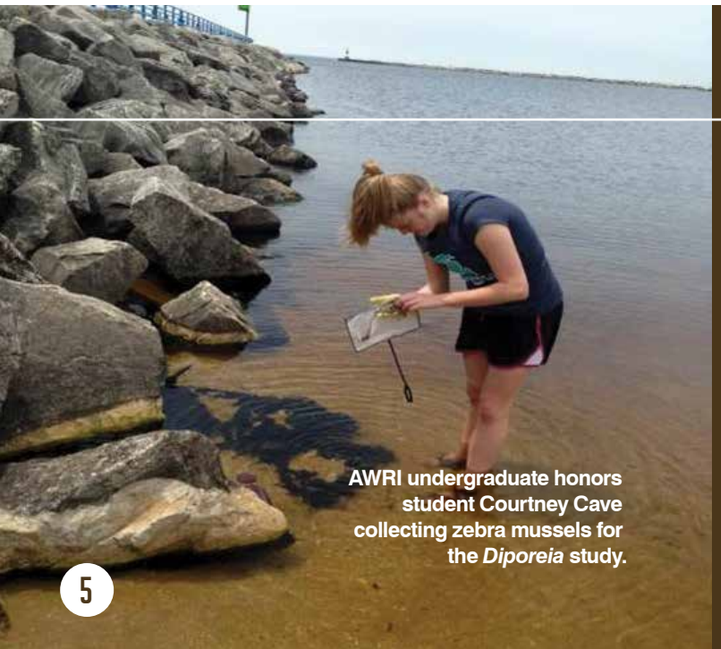
Invasive species have become a major problem worldwide, including in the marine environment. The Gulf of Mexico, like many other habitats, has experienced several major invasions from the Indo-Pacific. One particular invasion is by a coral called *Tubastraea coccinea*, or orange-cup coral. Over the past 60-70 years, it has invaded habitats from the Florida Keys to Brazil. Its favorite habitat appears to be oil and gas platforms, occurring in abundances of up to hundreds of thousands of colonies per platform. Kevin Strychar's lab is studying the genetic structure of these coral populations on oil platforms, determining their genetic relatedness, and assessing whether they are derived from a single or multiple introductions.

Invasive coral *Tubastraea coccinea* dominates oil platforms, resulting in loss of local species. Photo Credit: M. Bromschwig

SAVING CORAL REEFS: THE DEEP REEF REFUGIA HYPOTHESIS

Coral reefs are highly productive ecosystems threatened by climate change. Due to the rate and frequency of climate change, many organisms, including corals, are having difficulty adapting and acclimating. The "deep reef refugia" hypothesis states that deeper-water corals may have the potential to repopulate shallow depleted reefs. Graduate student John Skutnik is examining the expression of immune and stress genes in coral exposed to acute versus chronic heat stress. These results will help determine the resilience of these deeper-water coral and their usefulness as transplants to replace depleted shallow water reefs.

Graduate student John Skutnik collects coral at depths up to 110 feet in the Florida Keys.



AWRI undergraduate honors student Courtney Cave collecting zebra mussels for the *Diporeia* study.

ZEBRA MUSSELS LINKED TO DISEASE IN *DIPOREIA*

In 2013, undergraduate student Courtney Cave worked on identifying diseases in ***Diporeia***, a small shrimp-like organism that is a critical food source for bottom-feeding fish, as a possible cause of their decline in the Great Lakes. Finding a relationship, this summer she worked on identifying which invasive species is most likely the host of such diseases, with zebra mussels being the most likely culprit.

BUILDING MICHIGAN'S BLUE ECONOMY

Blue Economy roundtable meeting held at AWRI in October 2014. Photo Credit: URC (University Research Corridor)

Thanks to generous funding from the C.S. Mott Foundation, a joint initiative was started in 2013 between the Michigan Economic Center (MEC) and the Annis Water Resources Institute (AWRI). Project leaders John Austin (MEC) and Al Steinman (AWRI), along with student intern Devi Haria (AWRI), have been cataloging, inventorying, and exploring the Blue Economy activities taking place in our state's communities, businesses, and higher education institutions. We are examining the economic power and opportunity of our water resources, and how this vital natural resource can be utilized to drive an innovative water-based economy. The study's goals are three-fold: 1) help more Michiganders understand the blue economy, appreciate its current scope and influence, and examine what can be done to shepherd and enhance it; 2) provide examples and illustrations of how to build out the Blue Economy by describing what our people, firms, educational institutions, and communities are already doing - and how they are doing it to inspire and inform more activity; and 3) provide specific recommendations for strategic actions by leaders in state and local government, business, non-profits, education, and philanthropy to accelerate Michigan's Blue Economy growth. An interactive final report will be coming out in early 2015.

Graduate student Sarah Stamann conducts *E. coli* measurements of Flat River samples using the Colilert method.

LAB INVESTIGATES THE SOURCES OF NUTRIENTS AND *E. COLI* IN THE FLAT RIVER

Rick Rediske's laboratory is working with the Kent County Conservation District, Timmerman's Environmental, and Streamside Ecological Services to investigate the sources of nutrients and *E. coli* in the Flat River as part of a 319 Grant. The Flat River watershed is located in Kent, Montcalm, Ionia and Mecosta Counties and listed as a Michigan Natural River. The river supports a very high-quality smallmouth bass fishery, as well as populations of naturalized brook trout in several tributaries. While the biological communities in the river are rated good/excellent, water quality issues have resulted in concerns related to high nutrient loadings. This, in turn, has led to parts of the watershed being placed on the Michigan Department of Environmental Quality's 303(d) List of Impaired Waterbodies. AWRI is analyzing water and sediment samples in 2014 and 2015 to determine extent of nutrient and ***E. coli*** pollution in the watershed. The investigation includes dry and wet weather sampling events, in addition to groundwater and sediment measurements, to identify the pollution sources. Once sources have been identified, scent-trained dogs will be used to identify specific problem locations and the results will be confirmed with laboratory analyses. The project results will be used to develop a comprehensive watershed plan.

Graduate student James Smit (left) and research assistant Maggie Weinert (right) installing a turbidity sensor in the Macatawa River.

Project Clarity: Restoring the Macatawa Watershed

Project Clarity is a large-scale watershed remediation initiative aimed at dramatically improving water quality in Lake Macatawa and its watershed. Led by the Outdoor Discovery Center Macatawa Greenway, this major endeavor will take ~10 years and $12 million to complete. AWRI is serving as technical advisors and scientific consultants under the direction of Dr. Al Steinman. This includes conducting on-going field research, assisting with the development and implementation of restoration initiatives, developing and running watershed models, and building a restoration database. The many expected benefits of the project include increased property values, reduced human health and safety concerns, and improved ecological health.

As part of Project Clarity, AWRI initiated fish monitoring in Lake Macatawa to provide baseline data for assessing the response of fish to restoration activities in the watershed. The fish monitoring procedures allow comparisons to trends in Muskegon Lake, where AWRI has conducted long-term monitoring since 2003.

Research assistant Maggie Weinert with a northern pike captured in a fyke net in Lake Macatawa.

Understanding Harmful Algal Blooms

Graduate student Sarah Stamann collects a plankton sample from Silver Lake.

AWRI graduate student Sarah Stamann, with the assistance of graduate advisor Rick Rediske, is investigating toxin production and growth of a nuisance cyanobacterium in Silver Lake. *Gloeotrichia echinulata* has been reported in the lake and has formed dense blooms in previous years. Sarah is isolating *Gloeotrichia* from water samples to determine if it is producing the cyanotoxin microcystin and examining how phosphorus concentrations in the sediment influence its growth. This organism is the only cyanobacteria species known to obtain all of its phosphorus from the sediment. This information will be important in the management and understanding of harmful algal blooms.

Solutions for Clean Drinking Water

Robert B. Annis Foundation intern Jepkoech (JayJay) Kottutt examined the removal of arsenic by biosand filters modified with iron filings. Iron filings are a common waste product and her research shows they are effective in removing arsenic when they are used in a biosand filter. JayJay is developing an implementation plan and educational materials to use these filters in rural Kenya, her native country, as part of her Honors College Thesis.

JayJay Kottutt performing an experiment to test the removal of arsenic from drinking water.

Dr. Mark Luttenton collecting Lake Michigan sediments.

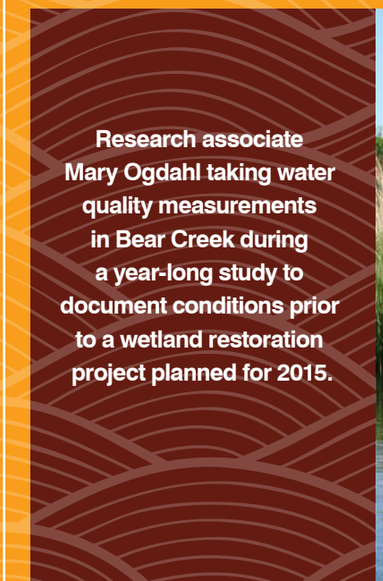
Great Lakes Fungi: a New Cure for Cancer?

Dr. Mark Luttenton is collaborating with a research team led by Dr. Robert Cichewicz at the University of Oklahoma to discover aquatic fungi that may produce compounds that could be used to treat diseases such as certain pediatric cancers. Sediment collected from the bottom of Lakes Michigan and Huron during summer 2014 has yielded an unexpectedly large number of fungal organisms, several of which have exhibited high anti-bacterial activity. The screening of selected compounds against cancer cell lines will proceed through the winter. The project, funded by the National Institutes of Health, will take four years.

AWRI at work

Undergraduate student Anna Harris with a common carp captured during boat electrofishing in Lake Charlevoix.

AWRI director Al Steinman taking water quality measurements in a stilling basin at the Holland Harbor Dredge Placement Facility, as part of Project Clarity.



Research associate Mary Ogdahl taking water quality measurements in Bear Creek during a year-long study to document conditions prior to a wetland restoration project planned for 2015.

AWRI research assistant Scott Kendall brings up the submerged Muskegon Lake Buoy Observatory for a mid-summer sensor check and mussel removal.

Graduate student Travis Ellens sets a fyke net in Duck Lake to sample wetland fishes.

Research associate Rod Denning collecting GPS coordinates near Sand Creek as part of a Forest Stewardship Plan.

Graduate student James Smit setting up a bioassay experiment in Silver Lake, MI, to determine algal responses to additions of nitrogen and phosphorus.

Research scientist John Koches (left) and student interns Jack Gibson (middle) and Chris Vandenberg (right) preparing to deploy an unmanned aerial vehicle (UAV) to evaluate tree planting efforts in the Muskegon River watershed.

MAKING THE GREAT LAKES GREAT THROUGH COLLABORATION

Dr. Janet Vail led a collaborative effort that united scholarship programs from AWRI, Michigan State University's Sea Grant Extension Program, and Inland Seas Education Association to provide custom-designed education and outreach opportunities for a variety of audiences. With funding from the Great Lakes Restoration Initiative (GLRI), on-board programs that included cruises, open houses, and workshops were conducted on two of the Great Lakes (Michigan, Erie), Lake St. Clair, and the Detroit River.

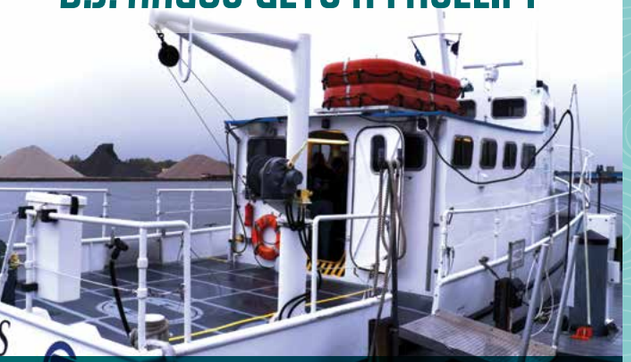
In 2014, the *W.G. Jackson* provided a variety of grant-supported summer programs for over 700 people in five ports of call in Lake Michigan, including Whitehall, Holland, and Muskegon, Michigan; and

Visitors attending an open house on the *W.G. Jackson* in Michigan City, IN.

Michigan City and East Chicago, Indiana. Partners in GLRI-supported Michigan events were the White Lake Public Advisory Council (Whitehall), Macatawa Area Coordinating Council (Holland), and Groundswell/ West Michigan Great Lakes Stewardship Initiative hubs (Muskegon). The Sanitary District of Michigan City and the Indiana Department of Environmental Management provided funding and organized events in Indiana.

Second grade students enjoyed their water study trip to AWRI, which was funded by the Alcoa Foundation. Additional support through 2016 from the Alcoa Foundation will continue to assist AWRI's outreach and education programs.

D.J. ANGUS GETS A FACELIFT



***D.J. Angus* at its mooring location in Grand Haven.**

A month of hard work by the AWRI vessel staff resulted in improved accessibility and docking for the *D.J. Angus*, providing easier access for passengers with disabilities and accommodations for wheelchairs.

AWRI's outreach and education team helps to provide professional development for teachers in the Groundswell and West Michigan Great Lakes Stewardship Initiative (GLSI) hubs.

Groundswell GLSI teachers explored restoration sites at Heritage Landing during their summer workshop.

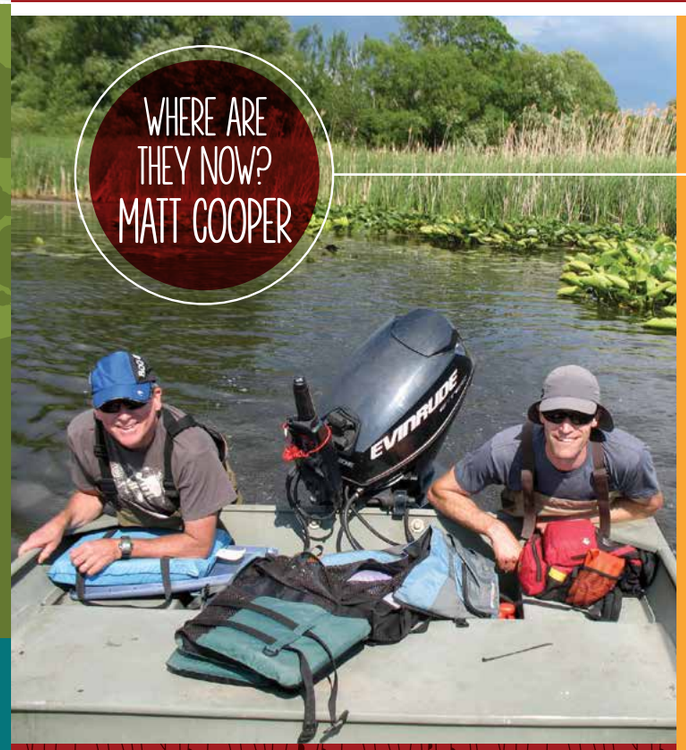
POSTDOCS MOVE ON

AWRI said goodbye to two postdoctoral research associates this year, as they secured new and exciting positions. Dave Janetski is now an Assistant Professor of Applied Aquatic Ecology at Indiana University of Pennsylvania, and Geraldine Nogaro has returned to her native country as a Researcher of Aquatic Ecology for the French utility, Electricite de France-EDF.

Dr. Dave Janetski

Dr. Geraldine Nogaro

WHERE ARE THEY NOW? MATT COOPER



CMU professor Matt Cooper (right) and his Ph.D. advisor Gary Lamberti (ND, left) in a coastal wetland on the Grand River.

Matt Cooper earned an M.S. in Biology at AWRI 2009, while working with Drs. Al Steinman and Don Uzarski, and a Ph.D. at the University of Notre Dame (ND) in 2014, under the supervision of Dr. Gary Lamberti. At both AWRI and ND, Matt's research focused on Great Lakes coastal wetlands, including studies on fish and invertebrate community structure, nutrient cycling, and wetland bioassessment techniques. Matt is now a Research Assistant Professor at Central Michigan University's (CMU) Institute for Great Lakes Research. Reflecting on his time at AWRI, Matt says: "I could not have asked for a better introduction to freshwater science. The mentoring that I received from all of the AWRI scientists in those years has been instrumental in my career." At CMU, Matt plans to continue focusing on Great Lakes coastal ecosystems, and says, "The Great Lakes are a globally significant freshwater system that is experiencing incredible changes. The better we understand this system, the more likely we are to manage it in sustainable ways."

GRADUATE STUDENT CHOSEN AS LEADERSHIP FELLOW

James Smit, who recently received his M.S. degree after finishing his thesis research in Al Steinman's lab, was accepted as a fellow in the 2014-2015 Peter C. Cook Leadership Academy, a leadership development program within the Hauenstein Center for Presidential Studies at Grand Valley State University. As part of his involvement in the academy, he has further developed his leadership skills by participating in Hauenstein Center events and receptions, attending high-profile community events, receiving professional training from Varnum Consulting, and engaging in other unique opportunities for leadership development.

Jared Homola is currently a Ph. D. student at the University of Maine in the School of Biology and Ecology.

A mottled sculpin infected with a fungal parasite, as evidenced by the disfigured abdomen.

How do parasites affect a non-game fish species?

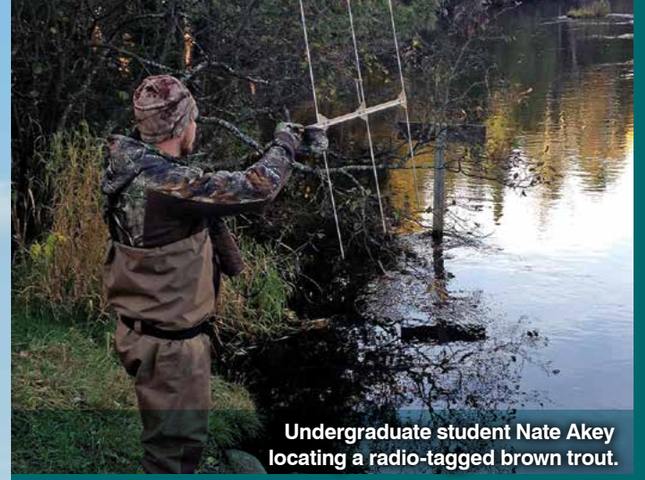
The effects of parasites on wild fish populations are unclear in many cases. For Jared Homola's master's thesis, he examined the effect of a fungal parasite on mottled sculpin, which is a small but important bottom-dwelling fish species, native to Michigan streams. Jared, working under the supervision of Dr. Carl Ruetz, surveyed mottled sculpin in 16 streams to 1) determine which populations were infected by the parasite and 2) examine the effects of the parasite on infected fish. This fungal parasite causes a disfiguring infection in the fish's abdominal cavity, and more than 50% of individuals in infected populations showed signs of the infection. Yet, Jared was unable to find strong effects of the parasite on mottled sculpin. Although this result was surprising at first, Jared ultimately concluded that his findings actually fit well with other studies of mottled sculpin that showed this species often has highly-stable population dynamics. Jared's study improves our understanding of the ecology of sculpin, which are an important component of many coldwater trout streams. The results of his study were published in the Canadian Journal of Fisheries and Aquatic Sciences.

Background Photo Credit: Travis Ellens

Undergraduate student Samantha Morsches, with David Janetski (background), holding a longnose gar captured and released in Stony Lake, Michigan.

SPATIAL PATTERNS OF FISH COMMUNITIES IN DROWNED RIVER MOUTHS

Technically called "drowned river mouths", the "lakes" that link tributary rivers to Lake Michigan are prominent features of Michigan's western shoreline. Student Summer Scholar Samantha Morsches, working with Drs. Carl Ruetz and David Janetski, surveyed fish along the shoreline of 15 drowned river mouths spanning a north-south gradient along Lake Michigan. The results from this study will provide valuable information about how fish communities change over a span of nearly 250 km of Lake Michigan shoreline and explore how those changes in the fish community are associated with environmental conditions and fish movement. Samantha is currently working with Dr. Ruetz to analyze the data collected this summer.



Undergraduate student Nate Akey locating a radio-tagged brown trout.

Graduate student Bryan Giordano (foreground) implanting a radio tag inside of a brown trout.

TRACKING BROWN TROUT MOVEMENT IN THE AU SABLE RIVER

To better understand brown trout ecology, Dr. Mark Luttenton, dozens of volunteers, several undergraduate students, and graduate student Bryan Giordano used radio telemetry to track nearly 50 brown trout over a 2-year period. Brown trout spent most of the year at a single location, typically a physical structure such as a log pile. Feeding movements occurred mostly at night when they would either move to a pool with slower flow or stay at their daytime resting site, making short forays in the area adjacent to that site. Except during the fall spawning migration, brown trout clearly prefer to be close to physical structure.

Supporting Collaborative Science at AWRI

At AWRI, we support and promote collaborative research opportunities by offering research space, equipment, and ship support facilities. In return, these visiting collaborators share new ideas with us, leading to more productive scientific projects. Several collaborations were made possible this year through our new Field Station and research vessel capabilities. Utilizing the *W.G. Jackson*, University of Michigan (UM) Ph. D. candidate Marian Schmidt studied bacterial diversity in Muskegon Lake. Kateri Salk, Ph. D. candidate at Michigan State University (MSU), conducted experiments on wetland sediment nutrient dynamics in the Field Station's Field Biology lab. Dr. David Fowle, a visiting sabbatical researcher from the University of Kansas (KU), is utilizing office and lab space in the Field Station.

Marian Schmidt (UM, foreground) and Edna Chiang (UM, background) on board the *W.G. Jackson* during a Muskegon Lake long-term monitoring cruise.

Kateri Salk (MSU) collecting sediment cores in former celery fields adjacent to Bear Creek.

AWRI FACULTY & STAFF

Photo Credit: James Smit

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

OUTREACH & EDUCATION:
Janet Vail, Associate Research Scientist
- Matt Bell, High School Intern
- Paula Capizzi, Lead Instructor *DJA*
- Paul Carlson, Science Instructor
- Cheri Gerhart, Science Instructor
- Ann Hesselsweet, Science Instructor
- Jessica Kastelz, Technical Call-in
- Shirley McIntire, Science Instructor
- Michele Smith, Science Instructor
- Diane Veneklasen, Science Instructor

GVSU VESSEL OPERATIONS:
Anthony Fiore, Jr., Fleet Captain
- John Bontrager, Captain *WGJ*
- Dave Fisher, Marine Engineer *WGJ*
- Kevin Fitch, Captain *DJA*
- Robert Marx, Deckhand *WGJ*
- Brad Nieboer, Marine Electrician
- Jim Rahe, Deckhand *WGJ*
- Gerry Weinert, Deckhand *DJA*

ECOLOGICAL RESEARCH, ENVIRONMENTAL CHEMISTRY:
Richard Rediske, Professor
- Jim O'Keefe, Research Associate
- Brian Scull, Research Assistant

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

ECOLOGICAL RESEARCH, ENVIRONMENTAL BIOLOGY:
Bopaiah Biddanda, Professor
- Leon Gereaux, Technical Call-in
- Scott Kendall, Research Assistant
- Michael Snider, Technical Call-in

Mark Luttenton, Professor of Biology
Jim McNair, Associate Professor
- Jon Minard, Intern, GVSU Computer Science

Carl Ruetz III, Professor
- Amanda Chambers, Technical Call-in
- Dave Janetski, Post-doctoral Researcher
- Stefan Tucker, Technical Call-in
- Jennifer Waller, Technical Call-in
- Andrya Whitten, Adjunct Research Assistant

Alan Steinman, Professor
- David Fowle, Visiting Sabbatical Researcher, University of Kansas
- Devi Haria, Technical Call-in
- Geraldine Nogaro, Post-doctoral Researcher
- Mary Ogdahl, Research Associate
- Kurt Thompson, Research Associate
- Maggie Weinert, Adjunct Research Assistant

Kevin Strychar, Associate Professor
Ryan Thum, Assistant Professor
- Greg Chorak, Technical Call-in
- Jeremy Newton, Adjunct Research Assistant

GRADUATE STUDENTS:
Nicholas Albrecht, AWRI Assistantship (major advisor: Mark Luttenton)
Delilah Clement, AWRI Assistantship (major advisor: Alan Steinman)
Travis Ellens, AWRI Assistantship (major advisor: Carl Ruetz)
Bryan Giordano, AWRI Assistantship (major advisor: Mark Luttenton)
Brandon Harris, AWRI Assistantship (major advisor: Carl Ruetz)
Josh Haslun, AWRI/MSU graduate student (advisor: Kevin Strychar)
Brianna Hauff, AWRI/MSU graduate student (advisor: Kevin Strychar)
Meagan McPherson, AWRI Assistantship (major advisor: Jim McNair)
Syndell Parks, AWRI Assistantship (major advisor: Ryan Thum)
Lindsey Schulte, AWRI Assistantship (major advisor: Ryan Thum)
John Skutnik, AWRI Assistantship (major advisor: Kevin Strychar)
James Smit, AWRI Assistantship (major advisor: Alan Steinman)
Sarah Stamann, AWRI Assistantship (major advisor: Rick Rediske)
Anthony Weinke, AWRI Assistantship (major advisor: Bopi Biddanda)
Jessica Wesolek, AWRI Assistantship (major advisor: Carl Ruetz)
Graeme Zaparzynski, AWRI Assistantship (major advisor: Mark Luttenton)
Brian Zuber, AWRI Assistantship (major advisor: Rick Rediske)

UNDERGRADUATE/GRADUATE STUDENT ASSISTANTS:
Nate Akey
Dana Collins
Paige Duncan
Anna Harris
Scott Metzdorf
Ryan Schiek
Emily Alverson
Emily Dean
Danielle Grimm
Zachary Kuzniar
Jeff Pashnick

INTERNSHIPS & SCHOLARSHIPS:
AWRI provides opportunities for students to pursue their interests in our environment. The following students received internships during 2014.

D. J. Angus-Scientech Educational Foundation Interns:
- Courtney Cave
- Andrew Pyman
- Chris Vandenberg
- Megan Zawacki

Herbert VanderMey Intern:
- Christina Hamilton

Robert B. Annis Foundation Interns:
- Jack Gibson
- Fallon Januska
- Jepkoech (JayJay) Kottutt

Bill and Diana Wipperfurth Scholarship:
- Ariana Carlson

Ron Ward Scholarship:
- Rachel Hughart
- Steve Ossim
- Jacob Burnham
- Jacob Chapman
- Jensen Simons
- Taylor Sparks

Student Summer Scholars (S3):
- Fatouma Abdoulaye
- Samantha Morsches

PEER-REVIEWED PUBLICATIONS 2014

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

Antonelli, P.L., S.F. Rutz, P.W. Sammarco, and **K.B. Strychar**. 2014. A coral bleaching model. Nonlinear Analysis: Real World Applications 16: 65-73. DOI: org/10.1016/j.nonrwa.2013.09.006

Borrowman, K.R., E.P.S. Sager, and **R.A. Thum**. 2014. The distribution of biotypes and hybrids of *Myriophyllum spicatum* and associated *Euhrychiopsis lecontei* in lakes of Central Ontario, Canada. Lake and Reservoir Management 30: 94-104.

Cooper, E.L., K. Hirabayashi, **K.B. Strychar**, and P.W. Sammarco. 2014. Corals and their potential applications to integrative medicine. Evidence-based Complementary and Alternative Medicine (eCAM). Volume 2014, Article ID 184959, 9 pages. DOI: 10.1155/2014/184959

Hauff, B.A.*, **J.A. Haslun***, J.M. Cervino, N. Krucher, A.M. Wier, A.L. Minnix, K. Hughen, and **K.B. Strychar**. In Press. Genetically divergent *Symbiodinium* sp. display distinct molecular responses to pathogenic *Vibrio* and thermal stress. Diseases of Aquatic Organisms. DOI: 10.3354/dao02802

Havens, K.E. and **A.D. Steinman**. In Press. Predicting the responses of a large shallow lake (Okeechobee, Florida) to climate change and potential future hydrologic regimes. Environmental Management. DOI 10.1007/s00267-013-0189-3

Homola, J.J.*, **C.R. Ruetz III**, S.L. Kohler, and **R.A. Thum**. 2014. Weak effects of a microsporidian parasite on mottled sculpin in Michigan streams. Canadian Journal of Fisheries and Aquatic Sciences 71: 915-926. DOI: 10.1139/cjfas-2013-0545

Isely, E.S., **A.D. Steinman**, P.N. Isely, and M.A. Parsell. 2014. Building partnerships to tackle conservation and management of West Michigan's natural resources. Freshwater Science 33: 686-692.

Janetski, D.J. and **C.R. Ruetz III**. In press. Spatiotemporal patterns of fish community composition in Great Lakes drowned river mouths. Ecology of Freshwater Fish. DOI: 10.1111/eff.12161

Madenjian, C.P., M.A. Stapanian, P.A. Cott, **R.R. Rediske**, and **J.P. O'Keefe**. 2014. Polychlorinated biphenyl concentrations of burbot *Lota lota* from Great Slave Lake are very low but vary by sex. Archives of Environmental Contamination and Toxicology 66: 529-537.

Madenjian, C.P., **R.R. Rediske**, **J.P. O'Keefe**, and S.R. David. 2014. Laboratory estimation of net trophic transfer efficiencies of PCB congeners to Lake Trout (*Salvelinus namaycush*) from its prey. Journal of Visualized Experiments 90: e51496. DOI: 10.3791/51496

Nielson-Gammon, J., S. Karpanty, W. Lauenroth, T. Martin, J. Nejstgaard, **K.B. Strychar**, P.D. Teel, R. Waskom, J.J. Wu. 2014. Chapter: Grand Challenge 3: Climate Change. In: Science, Education and Outreach Roadmap for Natural Resources, Association of Public and Land-grant Universities. pp. 38-49.

Nogaro, G. and **A.D. Steinman**. 2014. Influence of ecosystem engineers on ecosystem processes is mediated by lake sediment properties. Oikos 123: 500-512. DOI: 10.1111/j.1600-0706.2013.00978.x

Ogdahl, M.E. and **A.D. Steinman**. 2014. Factors influencing macrophyte growth and recovery following shoreline restoration activity. Aquatic Botany 120: 363-370. DOI: 10.1016/j.aquabot.2014.10.006

Ogdahl, M.E., **A.D. Steinman**, and **M.E. Weinert.** 2014. Laboratory-determined phosphorus flux from lake sediments as a measure of internal phosphorus loading. Journal of Visualized Experiments 85: e51617. DOI: 10.3791/5 16 17

Ruetz, C.R., III, **B.S. Harris****, **J.N. McNair**, and **J.J. Homola***. In Press. Removal and mark-recapture methods for estimating abundance: empirical and simulation results for mottled sculpin in streams. North American Journal of Fisheries Management.

Smith, S.D.P. et al. (18 authors including **A.D. Steinman**) In Press. Rating impacts in a multi-stressor world: a quantitative assessment of 50 stressors affecting the Great Lakes. Ecological Applications. DOI: 10.1890/14-0366.1

Stapanian, M.A., C.P. Madenjian, P.A. Cott, **R.R. Rediske**, and **J.P. O'Keefe**. 2014. Polychlorinated biphenyl congener distributions in burbot: evidence for a latitude effect. Environmental Toxicology and Chemistry 33: 2448-2454. DOI: 10.1002/etc.2703

Steinman, A.D., **M.E. Ogdahl**, **M. Weinert**, and D.G. Uzarski. 2014. Influence of water level fluctuation duration and magnitude on sediment-water nutrient exchange in coastal wetlands. Aquatic Ecology 48: 143-159. DOI: 10.1007/s10452-014-9472-5

Weinke, A.D.**, **S.T. Kendall**, D.J. Kroll, **E.A. Strickler****, **M.E. Weinert****, **T.M. Holcomb****, **D.K. Dila***, **A.A. Defore***, **M.J. Snider***, **L.C. Gereaux***, and **B.A. Biddanda**. 2014. Systematically variable planktonic carbon metabolism along a land-to-lake gradient in a Great Lakes coastal zone. Journal of Plankton Research 36: 1528-1542. DOI: 10.1093/plankt/fbu066

Xie, L., H.T. Hanyu, N. Futatsugi, M. Komatsu, **A.D. Steinman**, and H.-D. Park. 2014. Inhibitory effect of naringin on microcystin uptake in the freshwater snail *Sinotaia histrica*. Environmental Toxicology and Pharmacology 38: 430-437.

TECHNICAL REPORTS/MANUALS AND NON-PEER REVIEWED 2014

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

Biddanda, B. and **A. Weinke***. Changing carbon balance in the Great Lakes. InterChange. September, 2014. http://www.gvsu.edu/rmsc/interchange/connections-for-the-stem-classroom-299.htm

Denning, R. Bass River Watershed Atlas. MR-2014-1.

Denning, R. Deer Creek Watershed Atlas. MR-2014-2.

Herbert, J. and **R. Thum**. Keeping an eye on hybrid watermilfoils in Michigan inland lakes. Michigan State University Extension News, http://msue.anr.msu.edu/news/keeping_an_eye_on_hybrid_watermilfoils_in_michigan_inland_lakes

Herbert, J. and **R. Thum**. Stepping up to cooperatively manage your lake's aquatic plant community. Michigan State University Extension News, http://msue.anr.msu.edu/news/stepping_up_to_cooperatively_manage_your_lakes_aquatic_plant_community

Kendall, S., **B. Biddanda,** and **A. D. Steinman**. AWRI Summary Report of Water Quality Data from Wetlab's WQM Sensor on board GVSU's Windsentinel Buoy during 2012 and 2013.

Koches, J. and **A. Ebenstein****. Unmanned aerial vehicle (UAV) development with the citizen scientist in mind. National Water Monitoring News, Fall/Winter 2013, page 17.

Steinman, A.D. and **M.E. Ogdahl**. Muskegon Lake Area of Concern Stakeholder Involvement and BUI Removal Project: Bear Lake Wetland Restoration Area Monitoring. Final Project Report. November 2014.

Vail, J. Research Vessel *D. J. Angus* 2013 Use Report. CR-2014-1.

Vail, J. Research Vessel *W. G. Jackson* 2013 Use Report. CR-2014-2.

Photo Credit: Travis Ellens

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

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

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