2008 Water Resources year in Review

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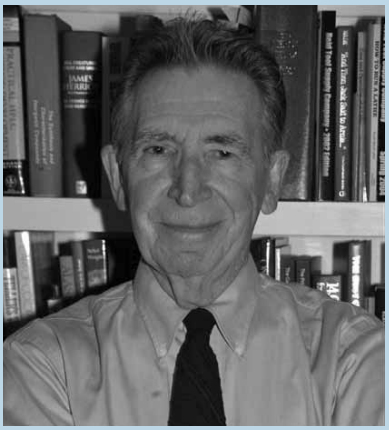

Dr. William Schroeder, Trace Analytical Labs

As the first chairman of the Muskegon County Environmental Coordinating Council, I was involved at the beginning in finding a home for AWRI. Since they were established, AWRI's impact locally has been significant. In the 60s, we had five stacks spewing sulfur dioxide all over the community, lakes bombarded with effluent from local industry, and no control over issues like these. But the change has been dramatic. Much groundwater contamination has been cleaned up, and the lakes are much cleaner.

AWRI has been very successful in terms of bringing attention to what's contaminating local lakes. This is something that had not been focused on in the past. AWRI is a leader in tracking issues such as run-off phosphorus and ammonia from lawn fertilization.

It's clear that the presence of AWRI, and the research and work they do, has a great impact on local environmental issues. They're a great group of people, and I know they will continue to be leaders in the community and work to solve the environmental problems we face now, and in the years ahead.

Keeping an Eye on the Environment

Dr. Alan Steinman, Director

Change is all around us. It's an integral part of our world in general, and paradoxically, it has been one of the constants at AWRI in 2008. As an institution, AWRI is changing programmatically to reflect sustainability initiatives and broad ranging environmental issues. Foci change over time, and now we're focused on "meeting the needs of today without compromising the ability of future generations to meet their own needs" (U.N. Brundtland Commissions 1987). While positioning AWRI to respond to new funding and research opportunities with an emphasis on sustainability, we are also on the forefront of local and regional initiatives that address sustainability.

As our physical environment changes, AWRI continues to modify its existing initiatives and develop expertise in new research areas. There is now a greater focus on climate change and its implications, as stronger storm events result in more intense run-off. This run-off, in turn, alters the ecosystem by adding more pathogens, sediment and nutrients to our water systems. In addition, climate change affects the Great Lakes. As a result, AWRI scientists are now focusing more effort on understanding climate change, land use change and sustainability, so we can understand the causes and consequences of blue-green algae blooms, storm-water runoff and climate change. For each area of study, we are also exploring the related implications on both economic and environmental levels.

Another change this year at AWRI is in our physical infrastructure. With assistance from Congressman Pete Hoekstra, we were able to build a new boat storage building this year; we incorporated "green building" elements, such as skylights and a green roof, to this structure. In addition, we planted a rain garden this year on our site, to treat run-off from our paved parking area. These accomplishments do not happen on their own — many thanks are extended to Tony Fiore for his oversight of the boat storage building and to Rod Denning for his leadership on rain garden design and construction. Finally, we are indebted to Kurt Thompson for his work on our new weather station. The AWRI Weather Station also includes a rooftop video camera, which streams live video of conditions on Muskegon Lake.

At the policy level, we continue to work on the official status of Principal Investigators (PIs) at AWRI. PIs are currently "administrative professionals" without tenure status, but there is a proposal in the works that hopefully will change this. In addition, AWRI's External Science Advisory Board will conduct their fourth review in March 2009. We anticipate their visit and feedback.

Graduate Student Matt Cooper

Matt Cooper has been conducting research, studying and learning at AWRI for the last six years. He first came in as a research assistant, and today he pursues both his studies as a graduate student in Dr. Alan Steinman's lab and his independent research. The two lines of research he's interested in concentrate on Great Lakes coastal wetlands. The first area centers on organisms such as fish and invertebrates. The second looks at biogeochemistry, which refers to how elements such as carbon or phosphorus cycle in nature. Cooper is particularly focused on how hydrology and wave action impact carbon cycling. "This really deals with the base of the food web," explains Cooper. "That's the direction I see my research headed in the future."

The project that involved the majority of Cooper's fieldwork in 2008 dealt with each of these topics: fish and invertebrate communities in coastal wetlands; and carbon cycling and community metabolism. "Looking at those two side-by-side, we try and determine whether the things that drive metabolism and carbon cycling — such as hydrology and human impacts — also affect fish and invertebrates. I'm studying how these communities respond to the changes humans bring, such as nutrient run-off from adjacent agriculture."

Cooper took community metabolism measurements from a range of Michigan wetland sites in 2006 and 2007. In summer 2008, in addition to gathering these data, Cooper and his crew also netted fish and sampled invertebrates at a selection of these sites. "It's cool at first to travel, but at some point it just becomes a lot of work," Cooper says as he thinks back on the fieldwork.

So far, the 2007 data show that wave energy correlates very well with the amount of "muck" or organic matter in the sediment. This, in turn, correlates with how much respiration occurs. Unlike photosynthesis, whereby plants take up carbon dioxide and release oxygen, respiration is the process in which organisms take up oxygen and release carbon dioxide. "If we can estimate the wave energy, then we have a really good idea of how much respiration there is," explains Cooper. That's important because respiration structures the communities that fish depend on, and fishing in the Great Lakes is a $4 billion industry.

GVSU student Alex Wieten helped Cooper process water samples.

Since GVSU does not offer a Ph.D. program in biology, Cooper's goal is to pursue a doctoral degree at another university by next fall. However, he certainly hopes to maintain collaborations with AWRI. "I love it here," remarks Cooper. "And, I understand these systems better than any others. Ideally, I would find another project through AWRI, so I can stick around. Over the years, it's really been a great place to be."

Combining Science and Policy

Dr. Alan Steinman's scientific interests have evolved over time. His first research interest was algae, and although he still has a deep and abiding interest in those organisms, his research experiences in the Pacific Northwest, East Tennessee, Baja California, the Florida Everglades and now the Great Lakes have broadened his interests considerably. This evolution is reflected in the research projects being undertaken in his lab, which focus on aquatic ecology, management and policy.

One of the key focal points in Dr. Steinman's lab is stormwater. Run-off from storm events can carry a lot of nasty pollutants, but it is very hard to regulate. As a consequence, Dr. Steinman's lab and colleagues at AWRI are involved in two large projects to address stormwater. First, an integrated assessment of stormwater is being conducted in the Spring Lake area. Managed by Elaine Sterrett Isely, a research assistant in Steinman's lab, this project looks at the environmental, social and economic aspects of stormwater, and will develop a suite of options to address the issue. Isely and Dr. Steinman are being assisted on this Michigan Sea Grant-funded project by researchers at AWRI, GVSU and ECT consulting from Ann Arbor.

The second stormwater project is funded by the US Department of Transportation, and takes a scientific approach to examining run-off entering Little Black Creek from Seaway Drive and US 31 in Muskegon County. This work involves many researchers at AWRI, and is also the basis for two graduate student theses: Kelli Johnson, who is working with Dr. Steinman; and Billy Keiper, who is working with Dr. Carl Ruetz.

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Dr. Steinman's lab is also involved in two projects in the Mona Lake Watershed that recently received funding from the Michigan Department of Environmental Quality (MDEQ). The first addresses whether the sediments in two flooded celery fields, located just upstream of Mona Lake, are a source of phosphorus to the lake. If so, the project will then focus on what sort of remediation techniques might solve this issue. The second project, led by the Mona Lake Watershed Council, involves the construction of a flow-through marsh (constructed wetland) along the upper parts of Black Creek. This marsh treats phosphorus and sediment that would otherwise flow down Black Creek and into Mona Lake. Leading these efforts in Dr. Steinman's lab are research assistant Mary Ogdahl and graduate student Matt Cooper.

Numerous studies have shown that a healthy and livable natural environment helps build a healthy economy. In order to protect and restore our green infrastructure, it is critical that we conduct the appropriate science and research. This is simply good economics; this information not only helps us decide on appropriate natural resource management decisions, but it also helps inform our funding priorities.

Graduate Student Jessica Higgins

Graduate student Jessica Higgins came to AWRI all the way from her home on the "other" West Coast, in Oregon. Ready for a change after high school, it was Aquinas College in Grand Rapids that first drew her to Michigan. After graduating with a Bachelor of Science in biology, Higgins began to explore her options at AWRI. However, she soon realized that most professors had already selected their student assistants. Thankfully, she says, she was lucky enough for Dr. Michael Chu to choose her as a graduate student. "When I first started looking, I really wanted to explore lake ecosystems," remembers Higgins. Although Dr. Chu's research focused on how water moves over landscapes, Higgins thought this was relevant to her initial aspirations because it examines general hydrology — how the land and water interact.

As part of this National Science Foundation-funded project, Higgins used a laser scanner and a rainfall simulator to gather her data. After constructing soil boxes, she began comparing run-off water differences both over rough versus smooth surfaces with the same soil type, and with two different soil types over the same rough surface. A Ph.D. student from China and two undergraduate students assisted in taking measurements relating to how water infiltrated the soil and flowed differently in these various conditions.

Higgins is still working on the findings, but so far she can definitively report that overland water flows faster on smooth surfaces than on rough surfaces. In addition, it appears that soil with more clay will have higher levels of erosion and cause water to flow into waterways quicker, and with greater force.

"Most of my data is going towards creating a Microsoft interface program that will help determine overland flow generation," explains Higgins. "Dr. Chu will create this program and then use it to educate students in high school and college about how different land forms increase or decrease runoff."

Higher levels of erosion and dramatic water flow both can have a negative impact on our waterways. So, Higgins' findings and eventually the computer program will help guide decisions about landscaping and construction. For example, it would be preferable to leave a degree of "rough" ground when landscaping, rather than clearing off plants and smoothing out the ground.

The completion of this work will result in Higgins receiving her Master of Science degree, which she hopes to complete in June 2009. With that date in mind, she has already started looking at jobs in everything from wildlife management to ecology. Although she has greatly enjoyed her studies in Michigan, she feels pulled back toward her home state and is exploring her options out West.

Higgins checks the wetting front during a simulated rainfall

Nuturing a Sustainable Future

Reports indicate that the climate is changing. Our air and water quality are being impacted. In view of these and many other concerns, one conclusion is certain: we need to learn to adapt. No, we don't necessarily need to adapt to life in a dramatically altered planet. What we need to do, as a community and as a race, is to adapt to live in a more sustainable manner.

For nearly eight years, John Koches, the AWRI Information Services Center (ISC) and many other collaborators have dedicated their time and talents to a sweeping project. This mammoth undertaking is the Muskegon River Ecological Modeling System, affectionately known as the Mega Model Project among investigators, which groups together a number of models to develop grand, definitive models of our environment today. Now, the time is finally approaching when the data will all be compiled and readied for dissemination, which is the aspect in which Koches and his group are most involved.

"There was an original concern with and interest in climate change, but no one had a way to understand or get a hold of that," shares Koches. "We first sought to use these models to inform management recommendations in terms of dam removal, setbacks or best management practices. Yet as it turns out, we can't really make these recommendations without having a clear understanding of what the climate might eventually be."

Climate projections call for more severe storm events and increasing temperatures into the next century for the Great Lakes region, leading to higher flows in rivers. It seems inevitable that the related greater erosion and sediment deposits will have a negative impact on water quality. "We can't spend millions of dollars on instream structures to protect shorelines when we don't know the eventual velocity of these waterways, or if these waterways will dry up. Management plans need to look to the future, and try to anticipate what's coming." Certainly, ISC's watershed management plans will take sustainability into account as they chart the future. Recognizing the change we've brought about in our environment through studies such as the Mega Model Project paints a sobering picture of why choosing a sustainable lifestyle is so important.

Heavy machinery was used to construct in-stream erosion controls in Sand Creek near Marne, Mich.

AWRI staff and volunteers plant a rain garden adjacent to Sand Creek in Marne, Mich.

A second arena in which Koches and ISC are active involves Geographic Information Systems, which are used to track and then understand land use changes over time. Research specifically deals with collecting high-resolution aerial photography in order to more accurately ascertain how humans are changing the environment on a macroscale as well as a microscale. The ISC team creates map products and models that are used by a variety of decision-makers.

Finally, there's the essential issue of sustainability, which is the concept that we as a community should provide for our own needs without impacting future generations. In this West Michigan community, researchers talk about the triple bottom line in terms of weighing economic, social and ecological goals equally. It's a cultural change in terms of looking at problems not only in consideration of the financial cost, but also of the cost to the community and the environment.

"We helped to organize the Muskegon Area Sustainability Coalition, made up of several groups that consider the triple bottom line," says Koches. Through this Coalition and various local and regional sustainability initiatives in which Koches is instrumental, hundreds of people have learned about sustainability.

"It's clear that the climate is changing due to human activities. What we're seeing now is something we've not seen in the lifetime of humanity; the only way to explain it is in terms of our impact," concludes Koches. To mitigate these changes, "we need to investigate what role our community can play, and how AWRI can contribute to any positive changes. This is just the beginning of this process, here in Muskegon and in the greater region."

AWRI researchers study the role of beach muck – Cladophora and Spirogyra algae – in the concentration of E. coli and microcystin in Saginaw Bay.

Tracking Our Impact

Did you ever drive up to a Michigan beach, only to discover that it was temporarily shut down? Or perhaps you did some Internet research before you left home, only to find in disgust that your favorite swimming hole was closed due to high levels of *E. coli*. If the beach is in Muskegon, Oceana, Mason or Manistee Counties, chances are that Dr. Rick Rediske helped keep you safe. Dr. Rediske's team spent a busy summer collecting data and monitoring these beaches for *E. coli*. These data helped inform the decisions of local health departments on whether or not to close recreational beaches. And although it's unpleasant to find your favorite beach closed for health reasons, the alternative could be much worse than just being disappointed.

The other two projects Dr. Rediske devoted his time to in 2008 involve toxic or harmful ecological changes in West Michigan waterways. First, Dr. Rediske continues the research he began in 2006 with cyanobacteria (blue green algae) and toxins. Toxins in the water both limit recreational use and are an issue for pet dogs who love the water. Simply stated, some species of cyanobacteria produce toxics, and in 2006, low levels of toxins were found in Muskegon Lake. However, these levels have since increased, and researchers want to know why. "Not only are the levels much higher now," says Dr. Rediske, "but the blooms of cyanobacteria persist longer."

At AWRI, Dr. Rediske collaborates with Dr. Ryan Thum, a molecular ecologist recently added to the staff, to see if there are genetic reasons for the persistence of these organisms in the lake. "We hope to use some of our new capabilities to help us resolve some of these issues," elaborates Dr. Rediske. "We hypothesize that there's one species of cyanobacteria with genetic differences that's accounting for the change. And, there is a possible link to global climate change; we'll have a graduate student looking at that as part of her Master's thesis."

Finally, Dr. Rediske is studying the levels of two chemical contaminants in fish: PCBs and PBDE. Dr. Rediske's research findings have revealed that PBDE, which is a material that makes plastics flame-retardant, is present in fish throughout Michigan — from the Les Cheneaux Islands in the Upper Peninsula to the Kalamazoo River. This chemical is detrimental not to the fish, but to the people who consume them.

"The Great Lakes are more susceptible to this kind of contamination because the residence time of water in Lake Michigan is about 100 years," explains Dr. Rediske. "We're now seeing the effects of materials put into the system in the '60s and '70s."And although his studies show that PCBs in walleye are also an issue, Dr. Rediske notes that cleaning up the environment will have a positive impact.

What's Driving the Hybrids?

Mention a "hybrid" in environmentally-conscious circles, and you'll likely be met with an approving round of smiles and affirmative nods. Yet while hybrid vehicles are a positive step towards making personal transportation more sustainable, "hybrids" don't always signify positive ecological change.

As a molecular ecologist, Dr. Ryan Thum utilizes specialized tools to address ecological problems dealing with the distribution and abundance of organisms. Currently, he is concentrating his research on milfoils, a diverse group of aquatic plants. Since native and nonnative strains of milfoils look extremely similar, the essential issue Dr. Thum focuses on is identifying which are native, which are nonnative, and which are hybrids of the two.

"Within the diversity of aquatic organisms, there's fundamental interest in trying to understand how evolutionary processes and ecological processes interact to shape patterns of biodiversity," remarks Dr. Thum. While

some of the work Dr. Thum performs is basic research, other aspects have more direct applications to society.

The problem of milfoils becomes clear when considering lake management. Especially in Michigan, people love their lakes. Yet an overabundance of milfoils can choke up the lakeshore, hamper recreation such as fishing, swimming and boating, impede drainage and ultimately drive down property values.

The nonnative species, such as the Eurasian water milfoil, tend to become big problems. Dr. Thum is intent on uncovering the genetic and ecologic factors that explain how these strains came to invade and thrive here.

The issue of hybridization makes the predicament infinitely more complex. Nonnative species hybridize with native species, and these hybridize with each other. "In regards to the hybridization issue, we're trying to figure out whether or not hybridization actually entails different forms of treatment," explains Dr. Thum. "We haven't found different outcomes so far in treatment methods, but people from lake associations certainly report that different strains react differently to different treatments."

So Dr. Thum tackles this problem from a genetic perspective. "This topic entails the question of whether there are scores of lineages for the hybrid strains, or really just a handful," he says. Ultimately, discovering the answer to this question through an analysis of the plant's genes will help in making management decisions about this nuisance plant.

If hybridization has happened in multiple places, there's a greater potential for diversity, and many different genotypes. And the more opportunity there is for genetic variation, the more opportunity there is for natural selection to select the ones that grow more aggressively. For example, there may be a parental strain and many hybrids in the lake. Herbicides may kill off all but one individual strain that has a combination of traits, allowing it to thrive, and eventually take over.

In the end, the way humans manage milfoils may create rapid evolutionary dynamics. Currently, the end-point of studying these plants' genes and then making management recommendations is far in the distance. "The reality is that you learn what you don't know every time you learn something in science," remarks Dr. Thum. Human activity distributes nonnative species to new locations, and humans are left to deal with the results. Hopefully, research like Dr. Thum's will both help us control the impact we've already had, and show us how we may avert such far-reaching negative influences in the future.

Matthew Zuellig, a graduate student working with Ryan Thum, sets up a field cage to compare growth rates of different genotypes of milfoil.

IT'S IN THE GENES

Current graduate students at AWRI almost certainly can't personally remember cell phones as big as bricks, typewriters with separate letter keys that leap to the page, or black-and-green, graphic-free computer screens. Technology has revolutionized all our lives in the last few decades, and that is especially true in the world of science.

Since the Institute began in 1986, advances in molecular biology have continued to provide AWRI researchers with new tools. Such tools help Dr. Mark Luttenton continue a collaboration that he's had for several years, studying the genetic makeup of brown trout populations in Michigan and Wisconsin. That's the simple overview. Specifically, one activity he's involved in entails looking at sections of genes in mitochondria, which are the primary organelle involved in energy metabolism in cells.

Dr. Luttenton and his longtime collaborator Alex Nikitin, of GVSU's Biology Department, use the genetic information they collect from Michigan and Wisconsin brown trout to identify their various origins. "Brown trout were first introduced to Michigan from Europe in the 1880s," says Dr. Luttenton. "By studying an individual trout's genetic makeup, we can determine both which region the trout's ancestors came from, and whether slight genetic variations impact the individual's function."

A specific genetic variation, however slight, may give an individual an advantage in one certain environment. From a management standpoint, these seemingly insignificant genetic variations could be used to determine which strains of brown trout will thrive optimally in

selected locations. In addition, this coldwater fish generally has a low tolerance for warmer water. Yet fish with special genetic variations could potentially fare better in our changing environment as water temperature elevates due to global warming.

Dr. Luttenton is also examining the ecology of headwater streams, looking specifically at algal production and food webs. He is currently seeking to identify the primary sources of energy utilized by aquatic invertebrates in headwater steams in the winter.

New Discoveries in the Deep

What's lurking beneath the surface of Lake Huron? Dr. Bopi Biddanda is on a mission to find out. Recently, his investigations led to a thrilling discovery: submerged sinkholes in Lake Huron. These sinkholes create unique underwater habitats that bear similarities to those found in thermal vent and sulfur spring environments.

As Dr. Biddanda and his team further explore these relatively accessible underwater ecosystems, new and exciting opportunities for microbial and geochemical studies continue to emerge. "Improved knowledge of the structure and function of these submerged sinkholes may ultimately lead to the protection and preservation of these unique habitats," shares Dr. Biddanda. Preservation is a major focus, since these sinkholes may be highly susceptible to human disturbances such as those created by land use changes.

These sinkhole studies are linked by carbon to another current focus of Dr. Biddanda's: carbon cycling. This may not be surprising, as carbon is the central element of life. On a basic level, carbon makes possible the existence of all organic compounds that are essential to our life on earth. By studying the carbon cycle, researchers can gain a greater understanding of how our ecosystem functions and how we can live more sustainably within it.

Research conducted by Dr. Biddanda on the carbon cycle of Lake Michigan and its adjacent water bodies may help answer several questions about this specific ecosystem. "For example, we aim to discover how the Lake ecosystem will respond over the short term to episodic events such as storms, and over the long term to ongoing climate change," explains Dr. Biddanda. In the future, Dr. Biddanda hopes to continuously monitor carbon fluxes in order to figure out whether these bodies of water serve as net sinks or sources of carbon dioxide to the atmosphere.

AWRI graduate student Angie Defore deploying sensors in Muskegon Lake.

Changing Expectations for Education and Outreach

Since 1986, thousands of students and other people simply curious about the world around them have experienced Lake Michigan and adjoining waters on AWRI vessels. This has included homeport cruises in Grand Haven and Muskegon, as well as trips of the *W.G. Jackson* to 31 ports of call in Lake Michigan, which were funded by the US Environmental Protection Agency. Although Dr. Janet Vailand the *D.J. Angus* and *W.G. Jackson* instructors have successfully managed AWRI's Water Resources Outreach Education Program for years, they recently incorporated the Michigan Department of Education's new "grade level content expectations" for science into all aspects of this program. It's this latest set of standards that necessitated a reevaluation of AWRI's education programs to assure that they are meeting statewide expectations.

Dr. Vail and the staff continue to educate students

Students learn about science and our environment in hands-on, innovative ways through AWRI's educational programs.

about the environment in innovative and intriguing ways through hands-on science on the vessels, and programs in the R.B. Annis Educational Foundation classroom. It is Dr. Vail'shope that "these ongoing educational opportunities will spark an interest in science and our changing planet in thenext generation." Dr. Vail shares that "students learn in different ways than in the past, and we are looking at updating teaching methods to accommodate the children of today." Most recently, new classroom programs such as "Salmon in the Classroom" and "Help the AWRI Scientist" have captured the imagination of students. Outreach education programs on AWRI's two vessels still serve many of the original groups, who have responded with positive evaluations of the changes that have been accomplished over the years.

The Water Resources Outreach Education Program is alert for opportunities to assist teachers through workshops and on-site visits. For example, this year two graduate classes for educators were offered at the Lake Michigan Center: "Introduction to Environmental Education" and "Human Population." Plans are in the works for a Climate Change workshop next summer. Finally, AWRI's Chemical Management in Schools grant from the MDEQ offers free training and resources, as well as assistance in evaluating school chemicals. Dr. Vail hopes to interest GVSU pre-service teachers in education opportunities and internships at the Lake Michigan Center: "We have a full complement of educational opportunities for a variety of audiences."

Working to Restore A Fragile Balance

At a basic level, many people may perceive that wetlands are important to our ecosystem, without necessarily basing this feeling in facts. Fortunately, Dr. Carl Ruetz's recent findings clearly reveal yet another facet of the intrinsic value of wetlands.

"We were interested in the question of whether or not Great Lakes coastal wetlands are resistant to the invasion to zebra mussels," says Dr. Ruetz. To find the answer, graduate student Kristin Nelson worked with Dr. Ruetz to study the colonization of zebra mussels in these wetlands and drowned river mouth wetlands. "Zebra mussels are an invasive species, and they cause issues in terms of changing the food web in the Great Lakes, as well as clogging water intake pipes." Humans changed the Great Lakes ecosystem by introducing these mussels, and the mussels now continue to spread due to common boating practices.

The data indicate that drowned river mouth wetlands are less suitable for zebra mussels as compared with adjacent lake habitats. Drowned river mouth wetlands have a fluctuating water chemical composition and physical variables such as turbidity that make them uniquely unsuitable for zebra mussels. As humans alter the environment, destroying Great Lakes wetland habitats for industry, housing and

Dr. Carl Ruetz holds a flathead catfish captured in a gill net set in Muskegon Lake during spring 2008.

Graduate student Kristin Nelson holds a lake sturgeon captured in the Muskegon River during summer 2008.

agriculture, realizing that not all wetlands are created equal may be of vital importance.

"Legislation protects wetlands, but often those wetlands more on the margins can be lost," says Dr. Ruetz. Even seemingly small shifts, like clearing away a wetland property line to accommodate a boat launch, can remove yet another area once resistant to zebra mussels and replace it with a habitat where they may thrive. "It's just one more reason to protect and preserve these special ecosystems," Dr. Ruetz contends.

The other study that occupied much of Dr. Ruetz's time in 2008 dealt with assessing the status of lake sturgeon in the Muskegon River. Humans decimated the original population of the once-abundant lake sturgeon, and today, it is a threatened species.

Amidst ongoing efforts to restore lake sturgeon populations and preserve the species around the Muskegon River, Dr. Ruetz and graduate student Matt Altenritter work to assess population status. "We can't restore the populations until we understand the basic biology and ecology of the species," explains Dr. Ruetz. One way they're building their understanding is with acoustic transmitters implanted in juvenile sturgeon. After tracking implanted fish, Altenritter will eventually plot their movements and study the patterns.

Since lake sturgeon can live upwards of 60 years, this data collection is just the beginning of a much larger future effort to try and restore populations to the levels they enjoyed before humans nearly wiped them out. "There's still a long way to go in terms of getting the Muskegon River back to its historic state, but at least lake sturgeon are not extirpated here as in other rivers," concludes Ruetz. "We can be happy about this and proud of it, but there's always room for improvement."

AWRI Faculty and Staff 2008 Highlights

Ecological Research Group

Dr. Bopi Biddanda (biddandb@gvsu.edu)

- Continued long-term collaborative work on pelagic metabolism in Lake Michigan using NOAA ship time. Published articles in Journal of Great Lakes Research and Limnology and Oceanography.

- Explored submerged sinkhole ecosystems in Lake Huron with NSF and NOAA funding. The project was chosen as NOAA's signature project for 2008-09. Published articles in Marine Technology Society Journal and Eos, Transactions, American Geophysical Union.

- Completed sixth year of AWRI's long-term environmental study of Muskegon Lake and completed the Muskegon River watershed and non-point source pollution study.

- Student projects studied the fate of carbon in Lake Michigan and the significance of microbial production at submerged sinkholes to surrounding Lake Huron food webs.

- Taught Biology 580: Ecosystem Biogeochemistry to graduate students; participated daily on web log activities for NOAA Lake Huron signature project (www.oceanexporer.noaa.gov) and in live broadcasts to schools across the USA (www.oceanslive.org). Prepared, presented and distributed to educators an education and outreach audio-video CD introducing the NSF-NOAA underwater research to elementary school children.

- AWRI Seminar Committee, College of Liberal Arts and Sciences Staff Advisory Council, Editorial Boards of Journal of Plankton Research and Aquatic Microbial Ecology. Panelist, Microbial Observatories Program — National Science Foundation.

Dr. Mark Luttenton (luttentm@gvsu.edu)

- Continued biological monitoring and assessment of the Henry's Fork River, Idaho, funded by the Henry's Fork Foundation
- Continued collaboration with Dr. Alex Nikitin of GVSU to examine the genetic identity of Michigan brown trout.
- Completed the nutrient loading study of White Lake, funded by MDEQ.
- Began working on the ecology of the Asian clam in the Grand River near Lansing, Michigan.
- Chair of the GVSU Graduate Council.

Dr. Richard Rediske (redisker@gvsu.edu)

- Obtained and completed a grant to develop a data base of historical concentrations of PCBs and mercury in fish collected from 15 Lake Michigan tributaries, funded by the Little River Band of Ottawa Indians.
- Obtained and completed a grant to determine the concentrations of PCBs and mercury in fish collected from 10 Lake Michigan watersheds, funded by the Little River Band of Ottawa Indians.
- Continued research concerning the ability of *Cladophora* to concentrate *E. coli* and microcystins in the nearshrore environment of Saginaw Bay and Grand Traverse Bay, funded by MDEQ.
- Appointed to the Michigan Department of Natural Resources Environmental Advisory Council and Green Chemistry Advisory Board.
- Continued research in fish contaminants and cyanobacteria toxins for grants with MDEQ, NOAA, and University of Michigan.
- Analyzed over 1,100 water samples for *E. coli* as part of Great Lakes beach monitoring programs for the Muskegon County and District 10 (Oceana, Mason, and Manistee Counties) Health Departments.
- Four peer-reviewed articles published.
- 15 Presentations: three invited technical, four contributed technical, eight invited community service.

Dr. Carl Ruetz (ruetzc@gvsu.edu)

- Continued long-term monitoring of fish populations in Muskegon Lake, funded by Muskegon Lake Research Fund.
- Initiated research to assess lake sturgeon reproductive and recruitment success in the Muskegon River.
- Three peer-reviewed articles published or in press.
- Six technical presentations; most co-authored with students.
- Mentored three graduate students completing thesis research and one undergraduate conducting a summer research project.
- Served as President of the Michigan Chapter of the American Fisheries Society.

Dr. Alan Steinman (steinmaa@gvsu.edu)

- Four new grants funded as PI or co-PI (~$140,000); three continuing grants as PI or co-PI (~$970,000).
- Nine peer-reviewed articles published or in press.
- 34 presentations: five invited (technical), eight contributed (technical); 18 invited (community service), three guest lectures (GVSU).

- Outstanding Reviewer Award, Journal of Environmental Quality (JEQ).
- Invited Member: International Joint Commission's Upper Great Lakes Study Public Interest Advisory Group and Ecosystem Technical Work Group.
- Invited member: Minnesota Sea Grant Advisory Panel.
- Invited Member: Science Advisory Panel for CMU's Great Lakes Biological Station (Beaver Island, Mich.).
- Panel Member, US EPA, Grants: Consequences of Global Change for Water Quality, Washington, DC.
- Invited Member: External Advisory Committee for University of Notre Dame's Global Linkages of Biology, Environment, and Society (GLOBES).
- Invited Reviewer: National Academy of Sciences "Progress Toward Restoring the Everglades."
- Associate Editor of Journal of North American Benthological Society.
- Program Chair, 2009 Annual Meeting of the North American Benthological Society.
- Foreign Examiner for Ph.D. Thesis of T.S. Harsha, University of Mysore, India.
- Monthly interview on WGVU-radio.
- Co-founder and co-organizer of Muskegon Café Scientifique.

Dr. Ryan Thum (thumr@gvsu.edu)

- Set up new facilities at AWRI dedicated to Aquatic Molecular Ecology.
- Used molecular markers to study dispersal and gene flow of invasive round gobies among pierheads along the eastern shore of Lake Michigan, funded by GVSU's Student Summer Scholar (S3) program.
- Used a combination of genetic analysis, field sampling, and laboratory experiments to conduct research into the genetic and ecological factors that govern evolution in species of water-fleas (*Daphnia*), funded by the National Science Foundation.
- Conducted ongoing research using a combination of molecular genetic analysis and ecological niche modeling to investigate the causes of biological invasions in aquatic plant species of water-milfoils (*Myriophyllum*).
- Three peer-reviewed articles published or in press.
- Mentored two graduate students and four undergraduate students conducting research.
- Conducted genetic analyses of putative invasive populations of water-milfoils for nine states. These identifications totaled over 150 plants from over 100 populations, and led to early detection of and rapid response to new invasive species in two states.

Information Services Center (ISC)
John Koches (kochesj@gvsu.edu) and ISC Staff

- Continued development of Environmental Indicators for the West Michigan Strategic Alliance Regional Indicators Project, funded by The Grand Rapids Community Foundation, Steelcase, and others.
- Continued support of the Muskegon Area Sustainability Coalition.
- Assisted in the creation of the second "Prosperity Index" for Muskegon County as part of the Muskegon Area Sustainability Coalition.
- Supervised Remote Sensing Event "Mars" for Michigan's 2007 Regional Science Olympiad.
- Continued support of the Muskegon River Watershed Mega Model Project, funded by the Great Lakes Fishery Trust.

- Continued work on the Muskegon River Watershed Education Project to create a Social Profile for the Brooks Creek Subwatershed, and working with four townships in this critical area to review and revise existing master plans and zoning ordinances to protect natural resources. Funded by MDEQ, the Wege Foundation and the Muskegon River Water shed Assembly Board.

- Continued support for the Grand River Watershed Project including website development and Information/Education programming.

- Began a new project titled Lower Grand River Organization of Watersheds Initiative, funded by MDEQ/US EPA.

- Completed update of the Rogue River Watershed Management Plan to meet the EPA nine criteria. Approved by MDEQ and funded by MDEQ/US EPA.

- Continued work on the White River Watershed to reduce the negative impact that pollutants are having on the watershed through the development and initial implementation of a stakeholder-driven watershed management plan. Funded by MDEQ/US EPA.

- Completed the White River hydrologic study and technical report approved by the MDEQ.

- Completed the Buck Creek 319 Project, which included *E. coli* monitoring, implementation of BMPs, education and information activities and updates to the Watershed Interactive Tool (WIT).

- Completed land use inventory, preliminary map atlas, hydrologic analysis (PLOAD, L-THIA GIS), and population modeling (PAM) for the Spring Lake Stormwater Project, funded by Michigan Sea Grant.

- Completed installation of new AWRI Weather Station, including the following weather instrumentation: temperature/relative humidity, barometric pressure, wind speed and direction and photosynthetically active radiaton (PAR). Also included with the station is a rooftop video camera to stream live video of conditions on Muskegon Lake.

- Completed the Sand Creek Watershed CMI Project, which included the creation of three bioretention areas (rain gardens), and the stabilization of 178 feet of stream bank along Sand Creek. Funded by the MDEQ/US EPA.

- Completed the Critical Lands Mapping Project in the Lower Muskegon River Watershed, funded by the Fremont Area Community Foundation – Ice Mountain Environmental Stewardship Fund.

- Continued work on the Lower Grand River Watershed Wetland Initiative to implement a functional wetlands assessment for the entire Lower Grand River Watershed, funded by US EPA.

- Completed work on the Urban Forest Ecological Services Assessment for the City of Grand Rapids, funded by JJR, Inc.

Outreach and Education Initiatives

Dr. Janet Vail (vailj@gvsu.edu) and Science Instructors

- Provided educational opportunities for over 6,000 people on the *D.J. Angus* and the *W.G. Jackson* research and education vessels.

- Facilitated activities for over 1,000 students and others in the LMC's Education Classroom and off-site. Supported by the R.B. Annis Educational Foundation Outreach Program Endowment.

- Presented educational cruises in Grand Haven, Muskegon, and Michigan City in Indiana as part of the Making Lake Michigan Great Tour of the *W.G. Jackson*. Funded by the US EPA Great Lakes National Program Office.

- Conducted educator training at venues such as the Global Change Workshop at Michigan Tech and MEECS Air Quality Unit training the Michigan Science Teachers Association conference.

- Offered two GVSU courses at the Lake Michigan Center for educators.

- Participated in "Salmon in the Classroom," career fairs and reverse job shadow events.

- Partnered with GVSU Regional Math & Science Center for GLOBE and other workshops.

- Coordinated Michigan Project WET and Project Webfoot, conducted workshops and trained new facilitators.

- Dr. Vail: became certified as a facilitator in Project Learning Tree and Project WILD.

- Continued the Chemical Management in Schools project, funded by the Michigan Department of Environmental Quality.

- Organized the 13th Annual Hazardous Waste Management Workshop in partnership with MDEQ and the West Michigan Chapter of the Air & Waste Management Association (A&WMA).

- Dr. Vail: Co-chair of the US EPA Lake Michigan Forum, Board of Directors of the Michigan Alliance for Outdoor and Environmental Education, Air & Waste Management Association West Michigan Chapter, and Great Lakes Association of Science Ships. Member of GVSU Grant Leadership Advisory Team, Environmental Studies Minor Development Team, and Center for Excellence in Science and Mathematics Education and the Regional Math and Science Center Advisory Boards.

AWRI Peer-Reviewed Publications (AWRI staff in bold):

Biddanda, B.A., S.C. Nold, S.A. Ruberg, **S.T. Kendall, T.G. Sanders** and J.J. Gray. In Press. Submerged Sinkhole Ecosystems in the Laurentian Great Lakes: A Microbiogeochemical Frontier. Eos, Transactions of the American Geophysical Union.

Biddanda, B.A., A. Steinman, L. Nemeth, Y. Hong and **S. Kendall**. 2008. Nutrient bioassays of plankton biomass and metabolism in an urbanized drowned river-mouth lake (Mona Lake, Michigan). Journal of Freshwater Ecology 23:41-53.

Breen, M.J., C.R. Ruetz III, K.J. Thompson and S.L. Kohler. In Press. Movements of mottled sculpins in a Michigan stream: How restricted are they? Canadian Journal of Fisheries and Aquatic Sciences.

Chu, X. and **A. Steinman**. 2008. Continuous hydrologic modeling improved by intensive event data, p. 1-11. In: World Environmental and Water Resources Congress, R.W. Babcock, and R. Walton. Ahupua'a [Electronic Resource]: World Environmental and Water Resources Congress 2008, May 12-16, 2008, Honolulu, Hawaii. Reston, VA: American Society of Civil Engineers.

Chu, X. and **A. Steinman**. In Press. Event and continuous hydrologic modeling with HEC-HMS. ASCE Journal of Irrigation and Drainage Engineering.

Cookingham, M.N. and **C.R. Ruetz III**. 2008. Evaluating passive integrated transponder tags for tracking movement of round gobies. Ecology of Freshwater Fish 17:303-311.

Cymbola, J.S., M. Ogdahl and **A.D. Steinman**. 2008. Phytoplankton response to light and internal phosphorus loading from sediment release. Freshwater Biology 53:2530-2542.

Fahnenstiel G.L., D. F. Millie, J. Dyble, R.W. Litaker, P.A. Tester, M.J. McCormick, **R. Rediske** and D. Klarer. 2008. Microcystin concentrations and cell quotas in Saginaw Bay, Lake Huron. Aquatic Ecosystems Health and Management 11:190-195.

Johengen, T.H., **B.A. Biddanda** and J.B. Cotner. 2008. Stimulation of Lake Michigan plankton metabolism by sediment resuspension and river runoff. Journal of Great Lakes Research 34:213-227.

Kerfoot, C.W., J.W. Budd, S.A. Green, J.B. Cotner, **B.A. Biddanda**, D.J. Schwab and H.A. Vanderploeg. 2008. Doughnut in the desert: late-winter production pulse in southern Lake Michigan. Limnology and Oceanography 53:589-604.

MacDonald, N.W., **R.R. Rediske, B.T. Scull** and D. Wierzbicki. 2008. Landfill cover soil, soil solution, and vegetation responses to municipal landfill leachate applications. Journal of Environmental Quality 37:1974-1985.

Madenjian, C.P., D.V. O'Connor, **R.R. Rediske, J.P. O'Keefe** and S.A. Pothoven. 2008. Net trophic transfer efficiencies of polychlorinated biphenyl congeners to lake whitefish (*Coregonus clupeaformis*) from their food. Environmental Toxicology and Chemistry 27:631-636.

Millie, D. F., G.L Fahnenstiel, J. Dyble, R. Pigg, **R. Rediske**, D.M. Klarer, R.W. Litaker and P.A. Tester. 2008. Influence of environmental conditions on late-summer cyanobacterial abundance in Saginaw Bay, Lake Huron. Aquatic Ecosystems Health and Management 11:196-205.

Ruberg, S., **S. Kendall, B. Biddanda**, T. Black, W. Lusardi, R. Green, T. Casserley, E. Smith, S. Nold, **T.G. Sanders**, G. Lang and S. Constant. In Press. Observations of the Middle Island sinkhole in Lake Huron: a unique hydrologic and glacial creation of 400 million years. Marine Technology Society Journal.

Steinman, A.D., M. Ogdahl and **M. Luttenton**. 2009. An analysis of internal phosphorus loading in White Lake, Michigan. In: Miranda, F.R. and L.M. Bernard. Lake Pollution Research Progress. New York: Nova Science Publishers.

Steinman, A.D., M. Ogdahl, R. Rediske, C.R. Ruetz III, B.A. Biddanda and **L. Nemeth**. 2008. Current status and trends in Muskegon Lake, Michigan. Journal of Great Lakes Research 34:169-188.

Steinman, A.D., X. Chu and **M. Ogdahl**. In Press. Spatial and temporal variability of internal and external phosphorus loads in Mona Lake, Michigan. Aquatic Ecology.

Steinman, A.D. and **M. Ogdahl**. 2008. Ecological effects after an alum treatment in Spring Lake, Michigan. Journal of Environmental Quality 37:22-29.

Thum, R.A. and A.M. Derry. 2008. Taxonomic implications for diaptomid copepods based on contrasting patterns of mitochondrial DNA sequence divergences in four morphospecies. Hydrobiologia 614:197-207.

Thum, R.A. and R.G. Harrison. 2009. Deep genetic divergences among morphologically similar and parapatric *Skistodiaptomus* (Copepoda: Calanoida: Diaptomidae) challenge the hypothesis of Pleistocene speciation. Biological Journal of the Linnean Society 96:150-165.

Technical Reports & Manuals 2008

De Mol, N. 2008. Addendum to the Rogue River Watershed Management Plan. MR-2001-1.

Denning, R. 2008. Critical lands mapping project, Lower Muskegon River Watershed, Muskegon County and Newaygo County, project atlas. MR-2008-2.

Hanson, B. 2008. Skeel/Cushman/Braton subwatershed hydrologic study. TM-2008-10.

Koches, J. and **R. Denning**. 2008. Critical lands mapping project – Lower Muskegon River watershed, final report grant evaluation. TM-2008-11.

Rediske, R., D. Uzarski, **X. Chu** and **M. Cooper**. 2008. Preliminary investigation of the extent of sediment contamination of Mona Lake Watershed. MR-2008-1.

Steinman, A.D., E.S. Isely, K. Thompson and P. Isely. Integrated valuation of ecosystem services tool. Available at: http://invest.wri.gvsu.edu

Stilson, T. and **De Mol, N.** 2008. Muskegon River Watershed Education Project Final Report. MDEQ Tracking Code 2005-9119.

2008 AWRI Staff

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Roger Hillstead, Maintenance

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Elliot Jagnecki, Technical Call-in
Matt Zuellig, Technical Call-in

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Tyler Armstrong, Biostatistics Master student (interned with Ryan Thum)
Matt Breen, AWRI Assistantship (major advisor: Carl Ruetz)
Melissa Conte (major advisor: Mark Luttenton)
Matt Cooper, EPA STAR Grant Fellowship (major advisor: Al Steinman)
Angela Defore, AWRI Assistantship (major advisor: Bopi Biddanda)
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Carson Prichard
Ben Sanborn
Michael (Ben) Stacey
Autumn Trombka
Jonathan VanderMolen
Dustin Wcisel
Maggie Weinert
Alex Wieten

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Harvey Bootsma, Great Lakes WATER Institute, U of Wisconsin – Milwaukee
Stephen Brandt, NOAA-GLERL
Carol Johnston, South Dakota State University
Gary Lamberti, University of Notre Dame
Don Scavia, University of Michigan, Michigan Sea Grant

AWRI provides opportunities for students to pursue their interests in our environment. The following students received internships during 2008.

D. J. Angus-Scientech Educational Foundation Interns:
Ben Sanborn
Autumn Trombka
Maggie Weinert
Alex Wieten

Herbert VanderMey Intern:
Megan Cookingham

AWRI Intern:
Carson Prichard

Air & Waste Management Intern:
Amanda Callaghan

Summer Student Scholars
Michael (Ben) Stacey

Bill and Diana Wipperfurth Scholarship
Michael (Ben) Stacey

Lt. Governor John Cherry speaking at public meeting held at the Lake Michigan Center, home of the Annis Water Resources Institute, describing Michigan's new plan to restore and preserve the Great Lakes of Michigan.

If you would like more information about AWRI's programs, please call us at (616) 331-3749 or (231) 728-3601; fax us at (616) 331-3864, contact us online at www.gvsu.edu/wri/ or write us at:
Annis Water Resources Institute
Lake Michigan Center
740 W. Shoreline Dr.
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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/development).

GRAND VALLEY STATE UNIVERSITY

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