

WISCONSIN SEA GRANT PROGRAM SUMMARY REPORT

Great Lakes Ecosystem Health



WSG has assessed the impact of round gobies in 75 tributaries of Lake Michigan, developed and implemented stormwater best-management practices at Milwaukee beaches and provided management strategies to control invasive cattails that wreck havoc in sedge meadows.



The Wisconsin Sea Grant (WSG) 2010-14 Strategic Plan includes among its focus areas one termed Enhance Great Lakes Ecosystem Health, which aligns with the national program's Healthy Coastal Ecosystem Focus Area.

WSG impacts and major accomplishments for 2008 through early 2012 either met or are on track to realize the strategies laid out in the 2010-14 strategic plan, which fall under the work areas of: **(1)** aquatic invasive species, **(2)** water quality, **(3)** ecosystems assessments, and **(4)** education and outreach.

AQUATIC INVASIVE SPECIES (AIS) STRATEGIES

- Use Sea Grant resources to engage researchers who can determine the social, physical and chemical factors that make water bodies prone to invasion by non-native aquatic species.
- Support research to assess and evaluate the near- and long-term effects of AIS on Great Lakes food webs, nutrient and contaminant transport, the impacts of AIS on Great Lakes aquatic resources.
- Support research to expand the array of tools to deal with AIS control and management, including ballast water treatment technologies and determine the financial costs of AIS on Wisconsin's Great Lakes resources and economies.

For many years, including 2008 and '09, WSG funded work on invasive cattails that wreak havoc in sedge meadows—the wetlands that foster ecological diversity, and provide homes and cover for birds, amphibians and small mammals.

Native cattail species typically grow straighter and sport sparser leaves that provide room for other plants. Invasive cattails crowd out other flora. The Nature Conservancy, NOAA's National Estuarine Research Reserve Program (NERR) and several management groups in both the United States and Mexico have adopted techniques developed through this WSG-funded research to reclaim native sedges from non-native cattail invasives in coastal areas.

The techniques include determining a species dominance index, which can chart both freshwater and salt marsh ecosystems; managing stormwater to regulate phosphorus loading; and encouraging fluctuating water levels since that is more likely to limit the shift from sedge meadow to cattail meadow than a stable water level.

Moving away from sedges into open water, a retrospective analysis of fish community structure by Jake VanderZanden at UW-Madison highlighted the historical effects of invasive species on fish populations in the Great Lakes. He used stable isotope analysis on tissue samples from hundreds of preserved fish species housed in museums across the country.



Asian carp threaten the Great Lakes' \$7 billion annual sport and commercial fishing industry. Our researchers are looking at the Lake Michigan food web and invasives' impact, and employing strategies to lessen that impact. Zebra and quagga mussels cost billions in clogged utility pipes and damaged infrastructure.



Wisconsin welcomes more than 600,000 registered boats. As each watercraft transfers from one body of water to another, there is the risk of spreading aquatic invasive species (AIS). Those species then disrupt the ecosystems of inland water bodies. In partnership with the Wisconsin Department of Natural Resources (WDNR), WSG manages a summer boat-landing inspector program to educate boaters along the Great Lakes. From 2008 to 2011, WSG's 31 inspectors reached 35,951 people, and nearly 17,000 boats were checked for aquatic invasive species. In the case of at least one species, quagga mussels, this education has proven effective. To date, there have been no reported discoveries of quagga mussels on any inland Wisconsin lake.

WSG's AIS advisory services specialist, Phil Moy, has undertaken many responsibilities to counter the spread of AIS. And, it is a big job. More than 180 non-native species have been confirmed in the Great Lakes. The costs to the region are at least \$200 million annually, and growing.

Since 1996, Moy has served as co-chair of the Army Corps of Engineers Dispersal Barrier Advisory Panel (now called the Technical Policy Work Group of the Asian Carp Regional Coordinating Committee) in

Illinois, convening semi-annual meetings that attract dozens of individuals and entities from around the Great Lakes basin.

In June 2009, the panel recommended the use of environmental DNA detection technology to assess the presence of Asian carp in the Chicago Area Waterways, which feed into Lake Michigan. This ultimately led to the discovery of Asian carp above a fish-repelling electric barrier installed in the Chicago area and a renewed interest in sealing off alternate routes of Asian carp spread as well as separation of the Great Lakes and Mississippi River basins.

Moy is also leading an innovative and collaborative approach to the challenge of AIS proliferating in Great Lakes waters. Working with the other Great Lakes Sea Grant programs, the National Professional Anglers Association, Cabela's Masters Walleye Circuit, The Bass Federation and Wildlife Forever, the initiative targets fishing tournaments and professional anglers as a vector in the spread of aquatic invasive species. Moy and his Sea Grant partner programs have worked with 34 tournaments, reaching 4,526 professional entrants and 230 youth competitors, although duplicates are likely. Surveys indicate that anglers take steps to prevent the spread of AIS. More than 600 children who participated in the Cabela's Masters Walleye Circuit kids' fishing clinics received AIS prevention materials. (See page 9 of the PRP report.)

Other targets for educational outreach are triathlon organizers and triathletes. In any given competition season, there can be hundreds of triathlons in the Midwest. These are laudable events for their promotion of physical fitness, yet at the same time, they run the risk of acting as a vector for the spread of AIS. Wet suits, course markers and safety watercraft used at triathlons move between events and water bodies. WSG has reached out to triathlon organizers and further work is pending, including adding AIS-prevention best-management practices to the 2013 USA Triathlon race directors' guide.

WATER QUALITY STRATEGIES

- Engage University researchers to determine the sources, transport and fate of bacterial and viral pathogens and chemical contaminants in the Great Lakes; evaluate the risks they pose to people and wildlife, develop tools and techniques to address these risks and communicate these solutions to Great Lakes users.
- Identify, develop and deliver methods to address and ameliorate the problems Cladophora causes for coastal communities, lakeshore power plants, beach goers and other Lake Michigan water users.
- Develop and communicate to marina and port operators through publications and outreach techniques to reduce the adverse water quality impacts of Great Lakes marinas, ports and other lakeshore facilities.

Beaches up and down the Lake Michigan coast have been affected by Cladophora, an algae that when decayed spoils recreation and lowers private property values. It has been linked to taste and odor problems in drinking water. In addition, it provides an environment that may sustain or exacerbate levels of *E. coli* and enterococci bacteria in beach sand and possibly swimming waters, threatening beach safety.

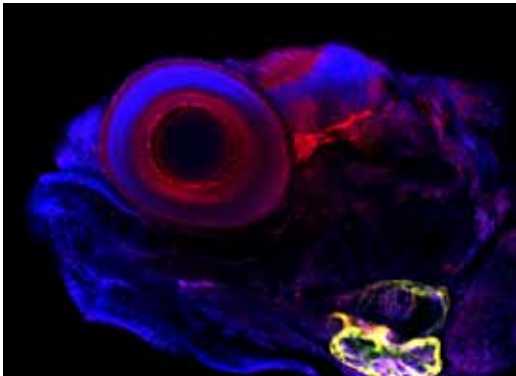
Increased Cladophora production in the late 2000s could have much to do with a "shunt" that delivers watershed-derived nutrients to the nearshore zones of the lake rather than supporting phytoplankton growth in the open waters. The invasion of zebra and quagga mussels, which filter vast volumes of water with both phytoplankton and nutrients, and in clearing the water above nearshore zones, allow more sunlight to reach multiple depths and encourage Cladophora growth.

WSG responded to the profusion of Cladophora by convening beach-manager meetings. There were 45 managers at a public forum in January 2009 and more than 75 at a research symposium in January 2008. Public health departments around the Great Lakes also have become interested in the effects of Cladophora and its bacteria-harboring ways. Representatives from Door, Kewaunee, Milwaukee, Ozaukee, Kenosha,

Racine, Manitowoc and Sheboygan counties attended WSG “Cladophora and Lake Michigan: Community Options for Management” meetings in 2008 and ‘09.

Local economies benefit from beach-related recreational tourism. Wisconsin 2011 figures reveal that beaches, water recreation and related water activities contribute to \$5 billion of tourism spending in coastal counties. One beach in Milwaukee, Wisconsin’s largest city, has capitalized on this tourism after years of beach closings and empty sands. In fact, in 2009 it even earned a coveted national Blue Wave Award from the Clean Beaches Coalition for its adherence to environmental ethics. What led to this turnaround? Dr. Sandra McClellan.

Research involving two small species, zebrafish and leopard frogs, yields big clues on ecosystem health. The World Health Organization adopted the fish-specific toxicity equivalency factors created by our research to gauge the risk of recruitment failure in feral populations exposed to toxics.



This WSG researcher developed a rapid testing method using DNA sequencing of sand and water samples (see page 3 of the PRP report). Research documented that stormwater significantly affected beach water quality. The work increased public awareness concerning the causes of beach closings. Such scientific information was critical in securing both public support for taxpayer investment and private funds to address contamination. Milwaukee County invested more than \$1 million in redesigning stormwater-management systems. Miller Brewing Co. invested \$500,000 into those improvements. These stormwater best-management practices led the way for other beaches to adopt similar models.

Another model with broad adoption is one developed by a WSG researcher and now in use by the U.S. EPA. It determines the behavior of toxic heavy metals in aquatic environments.

There has been further WSG work on toxics, in particular the effect of dioxin compounds on fish and how those effects eventually relate to feeding the world’s population; and blue-sac syndrome in fish populations and how that may relate to human maternal and child health.

The World Health Organization recently acted based on the work of two WSG researchers. The pair discovered that dioxin causes the ventricles of zebrafish embryo hearts to stop beating. That led the international body to set “relative potency factors” that regulatory agencies the world over can use to assess the risk of recruitment failure in feral fish populations exposed to the pollutants. That, in turn, has an impact on feeding

the world's hungry. If a nation cultivating fish to feed its population cannot rely on consistent yields, protein deficiencies follow. This impact is one derived from multiple years of research funding. These investigators frequently acknowledge that Sea Grant funding is the key to their translational research success and this impact represents true "research to (global) results" for this locally supported research.

Looking into blue-sac disease using zebrafish, these same researchers have now provided hatchery managers and aquatic toxicologists with a framework to predict heart defects that can lead to blue-sac syndrome in feral fish populations (see page 2 of the PRP report). Next, scientists will be able to develop biomarkers and assays to assess environmental conditions connected with fish health. Importantly, the work may also lead to the identification of heart teratogens women may be exposed to during pregnancy and, leading to fetal deaths.

Zebrafish are a small species, as are leopard frogs. Frogs, a single sentinel species in the Great Lakes region, offer a means to get a view of how the overall ecosystem fares. WSG-funded scientist Dr. William Karasov has determined that environmental toxins are bioaccumulating, proving lethal to some tadpoles.

If a tadpole survives and matures, toxins continue to affect its immune system, and hinder overall growth and development. It is the first time a specific class of dioxin-like contaminants, Polybrominated diphenyl ethers (PBDEs), have been linked to frog deformities. PBDEs, used as flame-retardants in consumer goods like computers and television sets, have been found at increasing rates in global ecosystems over the past two decades.

ECOSYSTEM ASSESSMENTS STRATEGIES

- Support research to improve the assessment and effectiveness of coastal habitat rehabilitation, restoration and remediation projects.
- Utilize Sea Grant outreach and communication products to provide technical support for citizens and businesses that need help with specific mitigation/ restoration problems, and provide them access to the latest information and techniques
- Contribute to the development of baseline data associated with physical, chemical, biological and geological coupling at Lake Superior and Lake Michigan land-water interfaces; work with state and federal partners such as NOAA's National Centers for Coastal Ocean Science to develop standards, and indicators to support ecosystem-based approaches for land use, water, fisheries, and other resource management and work .
- Support research to develop and improve models of Lake Michigan and Lake Superior food web dynamics.
- Develop a large-scale, partnered research program on the potential and realized impacts of aquatic invasive species on the Lake Michigan food web.
- Invest in the development and dissemination of new information, policies, technologies and methods to address water quality degradation, prevent the introduction and spread of aquatic non-native species, climate change and minimize the negative impacts of these on coastal, ocean and Great Lakes food webs.

Ecosystem assessments cannot be addressed by a single investigator and WSG has partnered within the Great Lakes basin for more reach and effectiveness.

Just as WSG works closely with Wisconsin's coastal communities, it also collaborates in an outreach capacity for research. In 2006, with regional research funding support from NSGO, WSG partnered with academic, governmental and private organizations to prioritize research needs by forming the Great Lakes Regional Research Information Network (GLRRIN). WSG's director was chosen as the co-chair of the Lake Michigan workgroup. WSG co-hosted a Lake Michigan GLRRIN workshop in Chicago in early 2008 at

which collaborators identified specific food web research needs for Lake Michigan. By partnering with Illinois-Indiana Sea Grant and pooling research funding, WSG released a special call for collaborative work to fill those gaps. WSG is currently in the second cycle of that funding.



Wild rice is a culturally important plant for the Ojibwe nation, whose members followed a divine prophecy seeking “food that grows on water” and migrated to Wisconsin hundreds of years ago. We have funded the development of molecular tools to ensure continued wild rice diversity and vitality in the Upper Great Lakes.

One ongoing project is mapping the Lake Michigan food web, taking into account the effect of invasive zebra and quagga mussels and contaminants on the system. A WSG-produced video at <http://bit.ly/LrYO16> provides further details. It has proven popular with those who want to learn more about the sustainable use of Lake Michigan. More than 1,400 viewers have tuned in.

On its Lake Superior coast, to determine research priorities with Minnesota Sea Grant WSG have teamed up, crafting 2009 and 2011 RFPs to solicit projects that will answer questions about estuarine and nearshore processes in the world’s largest freshwater lake. Through two research cycles, two projects have been funded. The first is nearing completion. It is assessing and mapping stressor gradients in the St. Louis River Estuary, which forms the border between Wisconsin and Minnesota. The second project just got underway and will assess the biogeochemical processes in this estuary.

By supporting collaborative research in this region, WSG helped the recently formed NOAA Lake Superior Estuarine Research Reserve (NERR) attract researchers in its early stages. WSG has also recently co-located an outreach field office at the NERR site in Superior, to better align activities to the benefit of both programs.

Lake Superior is the site of another research/ecosystem rehabilitation success story. WSG funded a Northland College biologist to develop molecular tools to study the genetic diversity of imperiled wild rice populations in Great Lakes coastal ecosystems (see page 5 of the PRP report). The researcher developed an inexpensive and rapid genetic-based test to identify wild rice diversity.

The molecular markers have been used to implement procedures to protect wild rice in habitats where it is declining or has been reintroduced. The markers have also been used to provide varietal protection to all publically owned types of cultivated wild rice, worth \$30 million annually to local economies.

Contaminants affect the viability of wild rice, and the larger Great Lakes ecosystem:

- More than 800 toxic contaminants have been identified in Great Lakes water and sediment.
- There are 43 Areas of Concern (AOC) in the Great Lakes.
- A 1990s study on 11 rivers that drain 90 percent of the Lake Michigan watershed determined that one river, the Fox in Wisconsin, contributed more mercury than the other 10 combined.

These sobering facts inspire WSG work and inspire researchers to add to the body of knowledge. One project, for example, deposited data regarding the expression patterns of Great Lakes fish tissues exposed to dioxin into public repositories. The data show how a particular class of dioxin alters the expression of genes in fish hearts, jaws and bodies. These data sets include more than 100,000 points and can be downloaded by anyone.

Implementing the beneficial use of dredged material to rebuild barrier islands in Green Bay, WSG outreach advisory services staff will inform the restoration of 1,400 acres of aquatic-based species habitat.



Further studies identified hundreds of rainbow trout and zebrafish genes that respond to sub-acute dioxin or mercury exposure. The findings are being used to evaluate the potential impact of persistent, bioaccumulative toxicants on feral fish populations in the Great Lakes and to provide information on the relative risk of toxicant exposures to humans that consume Great Lakes fish.

EDUCATION AND OUTREACH STRATEGIES

- Work with partners within and outside of NOAA to develop data, models, and training activities that support ecosystem-based planning and management and protection approaches, and share these with a wide variety of constituencies.
- Develop outreach and communications strategies to inform the public about what can be done to prevent the spread of invasive species and protect coastal water quality and habitat.

Research is one way to assess and address Great Lakes toxicology, and so is outreach and education. WSG staff have long served on EPA-convened remedial action plan and lake area management plan committees. In fact, WSG's water quality specialist co-chairs the U.S. EPA's Lake Michigan Lakewide Management Plan. A key initiative of that body during this reporting period has been a sustainable ports initiative.

The initiative has led to environmental assessment of ports in Muskegon, Mich., and Waukegan, Ill. Through the assessment, the managers of the port, marinas and industries along Muskegon Lake and Waukegan harbors gained a detailed picture of their facilities' impacts on Lake Michigan while learning ways to increase

environmental stewardship. The philosophy behind the initiative is that companies and municipal facilities can improve the quality of the local environment, and potentially their bottom lines, by moving beyond a narrow focus on regulatory compliance.

Back in Wisconsin, rapid watershed and coastal development, and industrial activities, have caused significant water-quality degradation in the Fox/Wolf River watershed in northeastern Wisconsin affecting the waters of Green Bay, an important estuary of Lake Michigan. WSG is leading efforts to restore this watershed, an area covering almost 500,000 acres.

Lake Michigan's coastal residents, farmers, stormwater managers and local officials will better understand the causes and consequences of excess algae production in Green Bay and Lake Michigan nearshore waters; along with learning about cost-effective best-management practices and will take actions to reduce nutrient and suspended solids runoff. That's all thanks to WSG's monitoring of Green Bay through its State of the Bay Report.

WSG's water quality specialist Vicky Harris prepared the report, which is an ecosystem health check-up for Green Bay. The report summarizes 42 ecosystem status and trend indicators, and captures multiple historic data sets, some of which had never before been published. The findings have been shared with hundreds of agency staff, local officials, scientists, citizen interest groups and the media. The WDNR and U.S. EPA revised the delisting criteria for the lower Green Bay and Fox River AOC and Remedial Action Plan in 2009 because of this report.

Furthermore, the WDNR and the U.S. EPA requested that WSG take the organizational lead on developing and implementing a Total Maximum Daily Load (TMDL) public education and participation strategy plan for the Lower Fox River, one of the largest such plans in the nation. The plan aims to reduce total phosphorus and suspended solids for the watershed. In the national TMDL guidance to states, the U.S. EPA lauded the Fox River TMDL public involvement and outreach program, and WSG's contributions, as a national model.

Also on the Fox River, WSG funded a longitudinal and comprehensive study to determine whether, and by how much, mitigation has helped lessen mercury concentrations. Another 10 tributary rivers that drain into Lake Michigan were also assessed. Preliminary results indicate that mercury concentrations are—at a minimum—not worsening and may in fact be declining around Lake Michigan. Such documentation will inform future remediation efforts and beneficial use of dredged material.

About beneficial use: Two of WSG's outreach advisory services staff members have teamed up to encourage the beneficial use of dredged material to rebuild barrier islands in Green Bay (see page 10 of the PRP report).

Working with an extensive list of local and federal partners, the Cat Island chain will again emerge from the waves to provide 1,400 acres of aquatic-based species habitat. The chain washed away due to high water levels, storms and extensive wave action refracted from hardened mainland shores in the 1970s. At every step of the 25-plus-year planning process to restore the islands, which was finalized in late 2011, WSG's water quality and habitat restoration specialist provided advice and assistance.

WSG has played a role in protecting many more coastal resources. In 2010, Wisconsin kicked off a Clean Marina Program and now has 19 certified clean marinas (see page 4 of the PRP report). That means the future will bring stronger businesses and cleaner waters. In order to receive certification marinas must follow practices such as preparing a petroleum-spill-prevention plan, washing boats away from the water and distributing clean-boater tip sheets.

Marinas and related industries and services contribute more than \$2.7 billion to Wisconsin's economy. The voluntary, industry-led Clean Marina Program gets its training and technical assistance from Gene Clark, a coastal engineering specialist, and Harris, who in 2010 earned a Lifetime Achievement Award from The Nature Conservancy. In 2011, she was nominated for a prestigious advisory-service award from the International Association for Great Lakes Research and received that honor in 2012.