WATER RESEARCH

AT THE UNIVERSITY OF TOLEDO

THE UNIVERSITY OF TOLEDO
1872

Overview

The University of Toledo has tremendous faculty depth and breadth in environmental sciences, environmental engineering, water treatment technologies, water policy and law, and environmental issues relating to public health. From 2012-17, UT received over $43 million in externally-sponsored awards to support environmental and water research, with much of the funding supporting interdisciplinary projects.

UT has been involved in research monitoring HABs in Lake Erie since 2002. UT has helped develop early warning systems to alert municipal water utilities of possible HAB events, providing utilities with the time necessary to take corrective action to protect drinking water supplies. UT also is involved in research investigating ways to detect toxins in water. After the "Do Not Drink" advisory in August 2014, the University put together an interdisciplinary taskforce of experts to help define and resolve issues around the many facets of this problem. For example, faculty have investigated invasive species and ways that climate change may affect the health of Lake Erie; developed engineered wetlands and other solutions to reduce nutrient loadings into Lake Erie; researched water treatment technologies and systems to remove cyanotoxins from home drinking water systems; studied ways to reduce urban stormwater events through management practices; investigated the linkage between recreational exposure to HABs and public health, such as through bathing, boating and jet skiing; identified hot spots for nutrient loadings in the Maumee Valley watershed and the effectiveness of agricultural practices in reducing nutrient loadings in waterways, and; investigated linkages between exposure to cyanotoxins and liver and other diseases.

The University also has specialized centers, institutes and laboratories to support this research including:

- The Lake Erie Center—a research, educational and outreach center on Maumee Bay, with a research vessel that monitors water quality on Lake Erie.
- Legal Institute of the Great Lakes in the College of Law provides analysis and education relating to legal and policy issues affecting Lake Erie and the Great Lakes.
- The College of Engineering Drinking Water Research Laboratory has a liquid chromatography mass spectrometer system and new flow cytometer used to detect various cyanotoxins and assimilable organic carbon, which is used by harmful microorganisms, to ensure the contaminants are not present in drinking water.

This document summarizes funded projects at the University highlighting both the breadth of work underway and the many federal, state and foundation sources supporting this work.

Table of Contents

The University of Toledo Water Task Force 2018

Name and Email	Area of Expertise
Task Force Chair **Calzonetti, Frank** Vice President of Research *Office of Research and Sponsored Programs* *Frank.Calzonetti@utoledo.edu*	• Energy Facilities • Regional Development
April Ames Assistant Professor *Public Health and Preventive Medicine* *April.Ames@utoledo.edu*	• Environmental and Occupational Health Public Health • Exposure Assessment • Risk Assessment
Apul, Defne Associate Professor *Civil Engineering* *Defne.Apul@utoledo.edu*	• Infrastructure Diversity • Life Cycle Assessment • Embedded Energy of Water System • Water-Food-Energy Nexus
Becker, Richard Associate Professor *Environmental Sciences* *Richard.Becker@utoledo.edu*	• Water Resource Availability • Watershed Modeling • UAV, Airborne and Satellite Hyperspectral and Radar Imaging • GRACE Gravity for Global Wetlands • Water Quality Remote Sensing
Bridgeman, Tom Associate Professor *Environmental Sciences* *Thomas.Bridgeman@utoledo.edu*	• Harmful Algal Blooms • Great Lakes Ecology • Dead Zones • Lake Nutrient Dynamics
Czajkowski, Kevin Professor *Geography & Planning* *kevin.czajkowski@utoledo.edu*	• Remote Sensing/GIS • Atmospheric Sciences • Hydrology • Land Cover

Name and Email	Area of Expertise
Dwyer, Daryl Associate Professor *Environmental Sciences* *daryl.dwyer@utoledo.edu*	• Improving nearshore health at Maumee Bay State Park by restoration of wetlands and riparian areas • Using real time environmental data to predict the occurrences of bacteria and microcystin for Lake Erie and inland lakes • Using bioberms and bioswales to capture nutrients and toxic contaminants from surface and subsurface sources
Egan, Kevin Associate Professor *Economics* *Kevin.Egan@utoledo.edu*	• Environmental economics • Non-Market Valuation • Benefit-Cost Analysis • Citizen's willingness to pay for water quality improvements
Fisher, Tim Chair & Professor *Environmental Sciences* *Timothy.Fisher@utoledo.edu*	• Geomorphology • Glacial and Quaternary Geology • Quaternary History of the Great Lakes
Gottgens, Hans Associate Chair & Professor *Environmental Sciences* *Johan.Gottgens@utoledo.edu*	• Wetlands ecology and management • Human impacts on rivers and streams
Gruden, Cyndee Associate Professor *Civil Engineering* *Cyndee.Gruden@utoledo.edu*	• Storm Water Management • Water Quality • Water Sensors
Haller, Steven Associate Professor *Cardiovascular Medicine* *Steven.Haller@utoledo.edu*	• Microcystin Hepatotoxicity • Non-alcoholic Fatty Liver Disease
Huntley, Jason Associate Professor *Medical Microbiology and Immunology* *Jason.Huntley@utoledo.edu*	• MC-LR Degradation • Biofilm • Microbiology • Gene Expression

Name and Email	Area of Expertise
Isailovic, Dragan Associate Professor *Chemistry & Biochemistry* *Dragan.Isailovic@utoledo.edu*	• LC-MS Quantification of Microcystins • Mass Spectrometry and Fluorescence Detection Techniques for the Identification and Quantification of Molecules in Water and Biological Samples
Kennedy, David Assistant Professor *Cardiovascular Medicine* *David.Kennedy@utoledo.edu*	• Microcystins and Human Health • Hepatotoxicity
Kilbert, Kenneth Professor of Law and Director *Legal Institute of the Great Lakes* *Kenneth.Kilbert@utoledo.edu*	• Law • Harmful Algal Blooms
Lawrence, Patrick Associate Dean & Professor *Geography & Planning* *Patrick.Lawrence@utoledo.edu*	• Water resource planning and policies with focus on Maumee watershed • Lake Erie & The Great Lakes River Restoration • Wetland Planning • Ten Mile Creek/Ottawa River
Lipscomb, Glenn Chair and Professor *Chemical and Environmental Engineering* *Glenn.Lipscomb@utoledo.edu*	• Reverse Osmosis • Membranes • Filtration
Mayer, Christine Professor *Environmental Sciences* *Christine.Meyer@utoledo.edu*	• Aquatic Ecology • Organism-habitat Modification • Introduced Species
Messer, Bill Professor *Pharmacology* *William.Messer@utoledo.edu*	• Neuroscience

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Rai, Saatvika Assistant Professor *Political Science* Saatvika.Rai@utoledo.edu	• Climate Change • Environmental Policy
Ruch, Randall Associate Professor *Biochemistry and Cancer Biology* *Randall.Ruch@utoledo.edu*	• Liver Toxicology • Carcinogenesis
Schultz, Jack Sr. Executive Director *Research Development* *John.Schultz@utoledo.edu*	• Molecular and chemical ecology • Plant biology • Research project development
Seo, Youngwoo (Young) Associate Professor, *Civil Engineering; Chemical and Environmental Engineering* *Youngwoo.Seo@utoledo.edu*	• Water Treatment Processes • Water Distribution Systems • Developing Water Quality Monitoring Sensors • Biofilm Control/Pathogen Disinfection
Snyder, Brenda Senior Research Associate *Environmental Sciences* *Brenda.Snyder@utoledo.edu*	• Cyanobacteria • Conventional Water Treatment • OEPA Drinking Water Regulations • Drinking Water Laboratory
Solocha, Andrew Associate Professor *Finance* *Andrew.Solocha@utoledo.edu*	• Economic Impact • Assets at Risk • Input-Output Models
Trease, Brian Assistant Professor *Mechanical, Industrial and Manufacturing Engineering* *Brian.Trease@utoledo.edu*	• Deployable structures • Mechanism design
Valigosky, Michael Assistant Professor *Public Health and Preventative Medicine* *Michael.Valigosky@utoledo.edu*	• Environmental Health • Public Health Remediation Contamination • Storm and Waste Water Management

Name and Email	Area of Expertise
Viamajala, Sridar Associate Professor *Chemical and Environmental Engineering* *Sridhar.Viamajala@utoledo.edu*	• Quantifying phototrophic growth and lipid-accumulation kinetics as influenced by simultaneous interactions between light, carbon dioxide concentrations, pH, temperature and nutrients • Strategies for economical downstream conversion of algal lipids to biodiesel • Influence of nutrient speciation on algal growth and lipid content

Ohio Department of Higher Education
Water Quality Research Initiatives

Following the 2014 "do not drink" advisory in Toledo, Governor John Kasich directed Chancellor John Carey to provide funding of $2 million per year to support research at Ohio's higher education institutions to address water quality issues in Lake Erie and other Ohio waterways. A Task Force was established, co-chaired by The University of Toledo and The Ohio State University, to develop a competitive merit-reviewed process to solicit research ideas from faculty throughout Ohio. Dr. Tom Bridgeman of UT is co-chair of this Task Force.

UT has been very aggressive in winning funds through this competitive process and has received over $2.1 million in support of this program. The following tables list the projects supported by the Chancellor's Water Quality program for each round of funding.

Round One

Focus Area	Project Title	ODHE Funds	Matching Funds	PI Last Name
Blooms: Sources and Movement	HAB Detection, Mapping and Warning Network: Maumee Bay Area	$248,297	$118,950	Bridgeman
Produce Safe Drinking Water	Investigation of water treatment alternatives in the removal of microcystin-LR	$199.998	$191,306	Seo
	Transport and Fate of Cyanotoxins in Drinking Water Distribution Systems	$106,209	$126,231	Seo
	Investigation of ELISA and interferences for the direction of Cyanotoxins	$75,011	$107,409	Isailovic
	Development of Microcystin Detoxifying Water Biofilters	$55,000	$78,740	Huntley
Protect Public Health	Method Development for Detecting Toxins in Biological Samples	$55,000	$70,621	Hensley
	Impact of pre-existing liver disease on microcystin hepatotoxicity	$55,000	$213,588	Kennedy
Educate and Engage	Maumee Basin Lake Erie HABs Stakeholder Informed Decision Making Support System	$66,501	$134,391	Lawrence
TOTAL		**$661,218**	**$1,041,236**	

Round Two

Project Title	ODHE Funds	Matching Funds	PI Last Name
Characterizations of recreational exposure to Cyanotoxins in Western Lake Erie	$21,213	$54,655	Ames
HAB Avoidance: Vertical Movement of Harmful Algal Blooms in Lake Erie	$208,145	$211,072	Bridgeman
Discovery of Enzymes and Pathways Responsible for Microcystin Degradation	$95,216	$119,392	Huntley
Evaluating Home Point-of-Use Reverse Osmosis Membrane Systems for Cyanotoxin Removal	$99,328	$146,143	Lipscomb
TOTAL	**$423,902**	**$531,262**	

Round Three

College	Title	Awarded Funding	PI Last Name
Health and Human Services	HAB Associated Health Effects and Airborne Microcystin Levels Among Recreational Lake Users	$133,737	Ames
Natural Sciences and Mathematics	Lake Erie Open Water HAB Impairment Criteria	$153,352	Bridgeman
Medicine and Life Sciences	Effects of Inflammatory Bowel Disease on Susceptibility to Microcystin-L	$149,715	Haller
Medicine and Life Sciences	Testing and Optimization of Microcystin Detoxifying Water Biofilters	$156,405	Huntley
Medicine and Life Sciences	High-Throughput Analysis of Human Toxicity and Therapeutics Targets of Cyanotoxins Across Organ Systems	$148,404	Kennedy
	Novel Therapies for Microcystin Induced Hepatotoxicity in Pre-Existing Liver Disease	$147,708	
Arts and Letters	Spatial Distribution Model for Manure from Permitted Livestock Facilities (CAFOs/CAFFs) in the Lake Erie Western Basin and Maumee Watershed, Ohio	$21,400	Lawrence
Arts and Letters	Effectiveness in Implementation: Mapping Agricultural Management Practices, Farmer Perceptions and Outcomes	$121,160	Rai
Total		**$1,031,881**	

Federal, Foundation and Other State Funding

Funding Awarded by the Great Lakes Protection Fund

Project Title: An Intelligent Cyberinfrastructure for the Decentralized Sensing, Modeling, and Control of Urban Stormwater

Principal Investigator: Cyndee Gruden **Funding Total:** $122,254

This project seeks to remediate the adverse impacts of large precipitation events to urban water systems by building and evaluating a real-time, decentralized stormwater management infrastructure. Researchers contend that green infrastructure efforts (rain gardens, bioswales, underground storage and buffer tanks, rain barrels, etc.) should be supplemented with intelligent and active control, to leverage real-time meteorological, hydrologic, and hydraulic sensor data to enable the adaptive and intelligent management of future stormwater systems.

Funding Awarded by the National Aeronautics and Space Administration FY 2009—FY 2017

Project Title: HICO Identification of Harmful Algal Blooms

Principal Investigator: Richard Becker **Funding Total:** $187,257

The Great Lakes provide drinking water and recreational use for approximately 40 million people, and are home to some of the most productive freshwater commercial and recreational fisheries in the world. Harmful algal blooms negatively impact all of these uses. This project uses both remote sensing data and in-lake data from permanent stations and field sampling to update and develop new algorithms for identifying different algal groups in Lake Erie.

Project Title: Mission Earth: Fusing GLOBE with NASA Assets to Build Systemic Innovation in STEM Education

Principal Investigator: Kevin Czajkowski **Funding Total:** $1,429,703

The MISSION EARTH team consists of geographically distributed partners committed to working with urban and rural high need school districts in the northeast, Midwest, southwest, and northwest, to produce national systemic change in STEM education. MISSION EARTH brings together scientists and science educations to develop a K-12 “Earth as a system” curriculum progression following research-based best practices.

Project Title: Inspiring Student Science Interest Through Real-World Climate Change Projects

Principal Investigator: Kevin Czajkowski **Funding Total:** $5,000

This project funds student research including: fieldwork, learning geospatial technologies through activities, and the production of an inquiry-based research project to present at the SATELLITES conference. Educators participate in a week-long institute that models project-based science pedagogy and then lead students through the program.

Funding Awarded by the NASA Glenn Research Center & Langley Research Center FY 2009—FY 2017

Project Title: Ground Data Acquisition & Processing for Hyperspectral Imaging of Harmful Algal Blooms (HABs)

Principal Investigator: Richard Becker **Funding Total:** $6,820

NASA Glenn Research Center is developing the method of using the hyperspectral imager on aircraft to take images of bodies of water to monitor and study the development of harmful algal blooms. This activity has intensified since the governor declared a State of Emergency in 2014 when HABs in Lake Erie left 400,000 citizens without municipal water. NASA’s hyperspectral image data requires calibration, and the calibration information must be acquired on land and over water. This project describes the effort needed for acquiring and processing the calibration data via ground and surface measurements.

Project Title: Hyperspectral Imager Atmospheric Correction

Principal Investigator: Richard Becker **Funding Total:** $42,000

NASA Glenn Research Center is developing the method of using the hyperspectral imager on an aircraft to take images of bodies of water to monitor and study the development of harmful algal blooms. This activity has intensified since 2014 when HABs in Lake Erie left 400,000 citizens without municipal water. NASA's hyperspectral image data requires calibration, and the calibration information must be acquired on land and over water. Atmospheric corrections need to be performed on this data to yield the true spectral shape for identification of algal content, and post-processing is required to turn data into information that enables water resource management decisions.

Project Title: Developing Online Protocol Modules to Engage Citizen Scientists for GLOBE

Principal Investigator: Kevin Czajkowski **Funding Total:** $73,362

The GLOBE program focuses on training teachers and students on Earth observations and development of research projects. Partnering with NASA Langley Research Center (LaRC), UT developed online presentation slides for the GLOBE Atmosphere protocols for online training modules, expanding the reach of GLOBE to more educators and students.

Funding Awarded by the National Oceanic and Atmospheric Administration FY 2009—FY 2017

Project Title: Early Bloom Mapping in Lake Erie

Principal Investigator: Richard Becker **Funding Total:** $55,000

The University of Toledo and Blue Water Satellite Inc. monitored Lake Erie Cyanobacteria to understand incipient bloom formation in terms of extent and duration. This investigation compares UT/Blue Water Satellite data with NOAA Lake Erie Experimental HAB Bulletin and ground sample data.

Project Title: A Harmful Algal Bloom and Water Quality Data Management Program for Western Lake Erie

Principal Investigator: Thomas B. Bridgeman **Funding Total:** $40,593

For the past 13 years, The University of Toledo Lake Erie Center (LEC) has routinely collected harmful algal bloom (HAB) and water quality data in western Lake Erie. Although data had been used in several scientific publications and had been made available to colleagues, the LEC lacked the capacity to "make the data available to a wider potential audience of data users and stakeholders." This project allowed the LEC to partner with LimnoTech, an experienced data management developer, to create a data management and communication (DMAC) system to provide the "local road" between the LEC data sets and GLOS, allowing increased access to archived data and a convenient portal for the LEC to provide data updates. The DMAC system fills a need for access to Lake Erie water quality data, particularly the intense interest in and requests for HAB data from a variety of stakeholders and fellow researchers.

Project Title: A Tool for Predicting the Spread of Invasive Species by Ballast Water

Principal Investigator: Jonathan Bossenbroek **Funding Total:** $9,993

This project objective is to create and dispense a flexible, user-friendly GIS tool that provides immediate information on the spread of invasive species to those who make decisions about ballast water management on the Great Lakes. The tool will use ballast water discharge information from ships traveling within the Great Lakes to identify the possible pattern of spread that may occur for invasive species that have already invaded the Great Lakes, or that may invade the Great Lakes in the future.

Project Title: Mapping Drain Tile and Modeling Agricultural Contribution to Nonpoint Source Pollution in the Western Lake Erie Basin

Principal Investigator: Kevin Czajkowski **Funding Total:** $76,307

The contribution of tile drains to nutrient loading to Lake Erie and formation of harmful algal blooms is unknown. With the high price of soybeans and corn in recent years, farmers have installed significant acreage of tiles on their fields, potentially increasing the effect of tile drains on the system. This project develops GIS layers of tile drains from aerial photographs and satellite images for all agricultural fields immediately surrounding Lake Erie, to investigate the potential input of nutrients due to increased use of tile drains.

Project Title: Coastal Modification Implications for Fish Communities

Principal Investigator: Christine Mayer **Funding Total:** $9,500

Working collaboratively with the Ohio Department of Natural Resources Division of Wildlife and ODNR Office of Coastal Management, this project (1) develops a protocol for the collection and classification of nearshore sediment samples, (2) develops a protocol for the collection, classification, and quantification of shoreline armoring and vegetation, and (3) develops a protocol for site characterization.

Project Title: Building Resilient Shorelines (Phase 1, 2, and 3)

Principal Investigator: Christine Mayer **Funding Total:** $211,613

This project refines existing nearshore assessment protocols and develops correlative relationships between coastal habitat structure and biological “hot spots” to further produce criteria needed to identify Priority Management Areas along the Western Basin (Huron, Ohio) shoreline. Research currently lacks relationships that connect specific vegetation attributes to measures of fish diversity; this study combines expanded analysis of existing fish community data with new measurements of vegetation attributes to refine previously reported general positive relationships.

Project Title: Model Development for Supporting Mitigating Western Lake Erie Harmful and Nuisance Algal Blooms

Principal Investigator: Song Qian **Funding Total:** $79,544

This project proposes a continuous Bayesian network (cBN) modeling approach to link Lake Erie spring phosphorus and nitrogen loadings to monthly microcystin concentration distributions due to harmful and nuisance algal blooms, in order to mitigate Western Lake Erie harmful algal blooms. This study uses spring nutrient loadings from the Maumee River to predict the monthly microcystin concentration distributions for annual forecasting of the risk.

Project Title: A Rapid and Accurate DNA Test for Invasive Fish Species from Water Samples

Principal Investigator: Carol Stepien **Funding Total:** $23,000

At least 186 invasive species are currently established in the Great Lakes, 25 of which are fish. Invasive species in the Great Lakes not only cause an estimated $5.7 billion annually in economic damages, they also have direct negative ecological impacts on indigenous wildlife populations via competition, predation, and habitat degradation. This project aims to develop, test, and apply a new quantitative PCR assay for environmental DNA to identify and quantify invasive fish species at all life stages from water samples. The outcome of an easy to use, rapid, and inexpensive test will allow for more efficient monitoring of invasive species and enactment of timely management policies to curb their spread.

Funding Awarded by the National Science Foundation
FY 2009—FY 2017

Project Title: Novel Lighting Source for Bioreactor Using Plasma-Shell Technology

Principal Investigator: Thomas Bridgeman **Funding Total:** $31,658

Under this SBIR, Imaging Systems Technology (IST) will develop a novel, highly efficient bioreactor lighting system based on IST's Plasma-Shell technology. Plasma-Shells are small, gas-encapsulating beads that emit light when energized. This research focuses on development and optimization of a unique Plasma-Shells lighting source that will significantly improve the efficiency of algae bioreactors and make them more cost effective.

Project Title: Extreme Events Impacts on Water Quality in the Great Lakes: Prediction and Management of Nutrient Loading in a Changing Climate

Principal Investigator: Thomas Bridgeman **Funding Total:** $56,045

The Great Lakes basin represents an extremely complex system, the water quality of which is directly linked to the viability and economic success of the country. This study develops an analytical system for the prediction of outcomes and feedbacks among the climate, biogeochemical, and social systems controlling water quality in the Great Lakes region. The focus is on the expected impact of climate-change-related extreme events on nutrient loading to the Great Lakes, with a focus on Lake Erie in order to take advantage of extensive ongoing data collection and research efforts.

Project Title: REU Site: Undergraduate Research and Mentoring-Using the Lake Erie Sensor Network to Study Land-Lake Ecological Linkages

Principal Investigator: Kevin Czajkowski **Funding Total:** $108,198

REU teams of undergraduate fellows, graduate students, and faculty members work as part of a larger established Land-Lake Sensor Network and an Environmental Science Learning Community at the Lake Erie Center to build synergistic and long-lasting professional collaborations with federal, state, and local agencies, NGOs, industry, educators, and other stakeholders. These teams address the complex ecosystem problems facing our nation.

Project Title: I-Corps: Reformulating spent lime as phosphorus-sorbing material

Principal Investigator: Daryl Dwyer **Funding Total:** $50,000

Research results related to reducing phosphorous levels in the local watershed via the use of phosphorus sorbent led researchers to use spent lime from water treatment plants to sorb phosphorus from water entering Lake Erie. The sorbent, now existing as phosphorus-enhanced lime, can be sold to companies that produce agricultural fertilizer in place of the mined limestone in current use. Thus, both water treatment facilities and agricultural suppliers will save money, and phosphorus that currently causes harmful algal blooms can be returned to an agricultural usage.

Funding Awarded by the Ohio Lake Erie Commission
FY 2009—FY 2017

Ohio | Lake Erie Commission

Project Title: BMP Development for Swan Creek Watershed Pilot

Principal Investigator: Kevin Czajkowski **Funding Total:** $15,000

Harmful Algal Blooms (HABs) on Lake Erie have been related to the increase in dissolved reactive phosphorous runoff from agricultural fields. Agricultural Best Management Practices (BMPs) have the potential to reduce runoff, or, in some cases, increase runoff. BMPs are voluntary practices designed to minimize the negative impact of agricultural production on the environment and water resources. This project works to understand the spatial distribution of BMPs and their use by farmers, knowledge of which will facilitate development of Watershed Action Plans

Funding Awarded by the Ohio Water Development Authority
FY 2009—FY 2017

Project Title: Using New Tools to Better Understand and Predict Harmful Cyanobacterial Algal Blooms in Lake Erie and Ohio Inland Lakes

Principal Investigator: Daryl Dwyer **Funding Total:** $59,899

In Ohio, local health officials have identified the presence of harmful algal blooms (HABs) during the summer and early fall seasons at some Lake Erie and inland lake beaches. HABs are caused by cyanobacteria that produce microcystin and other toxins. This project applies new tools over an entire season to better understand the link between cyanobacteria community structure, environmental and water quality factors, and HAB toxicity.

Project Title: Determining Components for a Phosphorous Interceptor to Reduce Harmful Algal Blooms in Lake Erie

Principal Investigator: Daryl Dwyer **Funding Total:** $7,087

Traditional best management practices implemented during agricultural conservation programs have mainly focused on nutrient management and reduction of nutrient transport off the fields, while ignoring treatment of subsurface tile drainage. This project addressed P emissions from tile drainage, using a prototype nutrient interceptor designed to remove soluble phosphorus prior to entering surface waters.

Funding Awarded by the U.S. Army Corps of Engineers
FY 2009—FY 2017

Project Title: Great Lakes Hydrilla Risk Assessment

Principal Investigator: Jonathan Bossenbroek **Funding Total:** $82,183

The monoecious biotype of hydrilla was recently discovered in the Cyuga Lake Inlet and in the Tonawanda Creek section of the Erie Canal in New York State, highlighting concerns about the spread of this invasive plant species throughout the Great Lakes basin. Eradication programs have been implemented at both sites. Recognizing that prevention is a key component of invasive species management in the Great Lakes, this project will result in a Great Lakes specific assessment of the risk hydrilla poses, with a specific emphasis on the monoecious biotype.

Funding Awarded by the U.S. Department of Energy FY 2009—FY 2017

Project Title: Direct Assessment Using Cluster Eddy-Covariance

Principal Investigator: Jiquan Chen **Funding Total:** $269,666

This project studies the impact of renewable biofuel systems on soil organic carbon stocks; it addresses the critical research need to provide direct measurements of soil carbon sequestered by different biofuel systems so that GWP can be considered in the choice of species and management options when developing new, renewable biofuel systems.

Funding Awarded by the U.S. Environmental Protection Agency FY 2009—FY 2017

Project Title: Assessment of Nutrient/Eutrophication Dynamics in Western Lake Erie

Principal Investigator: Thomas Bridgeman **Funding Total:** $165,043

Nutrient loading to the western basin of Lake Erie has been recognized as a pivotal component in the re-occurrence of harmful and nuisance algal blooms throughout the lake and hypoxia in the Central Basin. Through a combination of in situ experiments, laboratory studies, and modeling, this project improves current understanding of the roles of external and internal nutrient loading, especially as influenced by weather forcing events.

Project Title: Prevention of Surface Water Contamination from Biosolids Application

Great Lakes Restoration Initiative

Principal Investigator: Kevin Czajkowski **Funding Total:** $550,228

The application of biosolids to agricultural fields has become a common practice in many communities in the Great Lakes, especially in Northwest Ohio. This is viewed as a beneficial way to recycle a treated waste product from wastewater treatment plants. However, through DNA fingerprinting of *E. coli* and detection of PPCPs that are markers of biosolids, we have confirmed that contaminants from the biosolids are entering ditches and streams that flow into Lake Erie from tile drains. This project test pilots a control strategy of blocking the tile drain outlet as a pollution prevention technique. A sampling campaign will be performed to determine if this improves the quality of water leaving the tile drains.

Project Title: Maumee AOC, Wolf Creek: Passive Treatment Wetland to Improve Nearshore Health and Reduce Nonpoint Source Pollutants

Great Lakes Restoration Initiative

Principal Investigator: Daryl Dwyer **Funding Total:** $1,119,101

This specific project addresses the Beach Closing Beneficial Use Impairments (BUIs) by reducing bacteria, nutrients, and suspended solids in the watershed of Wolf Creek-Bergen Ditch, prior to its discharging into Maumee Bay within Maumee Bay State Park. The remediation and restoration project makes use of constructed wetland and is a priority project for the Maumee Remedial Action Plan (RAP), resulting in improved protection of public health and water quality at a public beach within a key AOC watershed.

Project Title: Reduction of Sediment and Bacteria Loadings to Public Beaches at Maumee Bay State Park via Enhanced Riparian Habitat

Great Lakes Restoration Initiative

Principal Investigator: Daryl Dwyer **Funding Total:** $472,491

This project focuses on removing sediment, nutrients, and bacteria from Wolf Creek to (1) reduce nonpoint source pollution to make beaches safer at Maumee Bay State Park (MBSP) and (2) restore/create riparian habitat. It complements and leverages other efforts in the Wolf Creek watershed remediation and restoration projects currently underway. The implementation project involves installation of a bed-load sediment collector and a sedimentation pond adjacent to Wolf Creek. These structures will remove significant quantities of sediment, nutrients, and bacteria prior to entering a wetland currently under construction at MBSP.

Project Title: Lake Erie Bathing Beach Monitoring

Principal Investigator: Daryl Dwyer **Funding Total:** $53,141

UT implemented a monitoring plan for the lakeside and inland beaches at Maumee Bay State Park (MBSP) to test for densities of *E. coli* for the 2012 recreational season. The results from the monitoring plan were used to inform the public and state agencies on the densities of *E. coli* at MBSP and when a swim advisory should be posted at the beaches.

Project Title: The Lake Erie Nearshore and Offshore Nutrient Study (LENONS)

Great Lakes Restoration Initiative

Principal Investigator: Christine Mayer **Funding Total:** $50,000

This project documents the quantity of nutrients in the major biotic and abiotic compartments of the nearshore and offshore pelagic and benthic habitats, particularly sediment nutrient sequestration, to elucidate drivers of the Lake Erie trophic paradox. It documents uptake rates of bacterioplankton, phytoplankton, and benthic algae, and assesses water column and sediment bacterial community composition. Research will relate these uptake rates and community dynamics with nutrient pool sizes using hydrodynamic models of particle transport to assess whether the pools of nutrients in the nearshore and offshore regions of Lake Erie follow predicted patterns of early lake mixing models, and to determine how the current state of nutrients match historical conditions. This study may be particularly relevant to understanding stoichiometric imbalance in Lake Superior by providing data from portions of Lake Erie that may serve as both a comparison for Lake Superior (offshore in the eastern (basin) and as a stark contrast (nearshore in the western basin).

Project Title: Using DNA for Early Detection of High-Risk Invasive Fish Species

Great Lakes Restoration Initiative

Principal Investigator: Carol Stepien **Funding Total:** $150,000

This project seeks to develop an accurate DNA-based diagnostic test on water samples that will enable the early detection of high-risk invasive fish species. The test is intended to be easy to use, rapid, and inexpensive. It is intended to be effective even in the presence of very small fish populations, and will be able to detect the presence of fish regardless of their life-stage (e.g., eggs, larvae, or adults).

Project Title: Early Detection of Invasive Fish Species

Great Lakes Restoration Initiative

Principal Investigator: Carol Stepien **Funding Total:** $598,922

This project identifies and quantifies high-risk invasive fish species from Great Lakes water samples, using targeted DNA sequences. Outcomes of the project should: (1) improve the ability to detect invasive species at low population levels to facilitate rapid response actions, (2) help stop the introduction of new invasive species into the Great Lakes through surveillance, and (3) control and reduce the spread of invasive species already in the ecosystem through the provision of up-to-date, critical information needed by decision makers.

Project Title: Invasive Invertebrate Species Prevention, Detection, and Control: A New Generation Sequencing Assay

Great Lakes Restoration Initiative

Principal Investigator: Carol Stepien **Funding Total:** $499,964

This project focuses on invasive invertebrate species that have potential for, or are causing, serious ecosystem impacts in the Great Lakes and/or moving between the Great Lakes and the Mississippi River system. Project outcomes will: (1) help stop the introduction of new invasive species in to the Great Lakes, inland lakes, and the Mississippi River system through enhanced surveillance and prevention programs, (2) control and reduce the spread of invasive species already in the ecosystems through enhanced on-the-ground and in-the-water efforts, providing up-to-date critical information needed by decision makers, and (3) improve the ability to detect invasive species at low population levels to facilitate rapid response actions.

Project Title: Invasive Species Prevention from Retailers to Metagenetics, Supply Chains, and Public/Stakeholder Engagement

Great Lakes Restoration Initiative

Principal Investigator: Carol Stepien **Funding Total:** $499,991

Little has been done to prevent nonnative species entering the Great Lakes through bait, outfitter, pond supplier, and/or pet store purchases. Invasives frequently are indistinguishable from natives at early life history—even to taxonomic experts. This project analyses retail fish and mollusks and evaluates their concomitant water and plants using new DNA diagnostic assays (developed during existing GLRI funding) to: (1) detect, identify, and quantify all invasive species even at rarity, (2) diagnose supply chain sources, vectors, and pathways, (3) pilot a voluntary “Invasive Free” certification program for retailers, and (4) disseminate findings targeting prevention.

Funding Awarded by the U.S. Fish and Wildlife Service FY 2009—FY 2017

Project Title: A Multifaceted Urban Stream Restoration Project for the Ottawa River

Great Lakes Restoration Initiative

Principal Investigator: Patrick Lawrence **Funding Total:** $60,000

This project will restore, enhance and create 1,900 feet of a contiguous habitat along the Ottawa River located on the main campus of The University of Toledo (UT), within the City of Toledo between RMs 10.8 and 11.2. Service funds will more than double current stream restoration efforts (900 feet) to address the critical issues of aquatic habitat loss and stream bank restoration and stabilization - that have been identified as significant environmental concerns for the river.

Project Title: A Multifaceted Urban Stream Restoration Project for the Ottawa River

Great Lakes Restoration Initiative

Principal Investigator: Patrick Lawrence **Funding Total:** $54,132

This project will complete the restoration of 3,700 feet of a contiguous habitat along the Ottawa River located on the main campus of The University of Toledo (UT), within the City of Toledo between RMs 10.8 and 11.2. Service funds in 2011 addressed initial planning and design. Additional funding (this project) will support the construction of a cut bank structure that is deemed necessary for flood water storage.

Project Title: Maumee River Larval Walleye Data Analysis

Principal Investigator: Christine Mayer **Funding Total:** $12,000

The Maumee River provides important spawning grounds for walleye (*Sander vitreus*), an economically and ecologically important fish in Lake Erie. The Maumee River supports a spring fishery for walleye and contributes a sizable number of fish to the overall Lake Erie Stock. This project helps determine the number of fish exported from the Maumee River to help fishery managers quantify the importance of the Maumee stock to the overall lake population.

Project Title: Larval Walleye Abundance Estimation in the Maumee River

Principal Investigator: Christine Mayer **Funding Total:** $20,723

The Maumee River is thought to provide spawning habitat to an important stock of Lake Erie walleye; however, the relative sizes of Western Basin spawning stocks are unknown. This project provides an accurate estimate of the number of larval walleye exported from the river to Lake Erie. Data from this project on dates and densities of larval walleye will be provided to researchers at Ohio State University to use in a biophysical model of larval fish movement across the Western Basin.

Project Title: Maumee River Lake Sturgeon Restoration Plan

Principal Investigator: Christine Mayer **Funding Total:** $99,981

The University of Toledo will assess lake sturgeon habitat in the Maumee River downstream of Defiance Dam, including Maumee Bay. Using characteristics tested in previous habitat suitability studies, researchers will develop a spatially explicit model to evaluate if the Maumee River is suitable for multiple life stages of lake sturgeon, and, ultimately, create a restoration plan for lake sturgeon in the Maumee River.

Funding Awarded by the U.S. Forest Service FY 2009-2017

Project Title: Phytoremediation of Brownfields in Toledo, Ohio

Principal Investigator: Daryl Dwyer **Funding Total:** $478,276

Contamination of urban brownfields hinders redevelopment opportunities, jeopardizes the health of area residents, and compromises the chemical, biological, and physical integrity of the Great Lakes watershed. This project uses phytotechnology to aid in the redevelopment of three urban brownfields in Toledo, Ohio. Native species will be used to help restore the environmental and ecological integrity of the Great Lakes watershed, which contains delicate ecosystems such as Oak Openings and Maumee Bay. Completion of the project will result in 70 acres of urban land made available for redevelopment, and will serve as a working example for the transfer of phytotechnologies through the Great Lakes region.

Funding Awarded by the U.S. Geological Survey FY 2009—FY 2017

Project Title: 9-Element Watershed Plan Update

Principal Investigator: Daryl Dwyer **Funding Total:** $5,734

This project provided technical support to prepare three 9-element watershed implementation strategies. In conjunction with the City of Toledo and Ohio EPA, the PI provided technical writing services to research, write, and produce the plans for the mutual benefit of future collaboration and restoration projects in the watersheds.

Project Title: Determining the Contribution of Maumee River Fisheries Production to Western Lake Erie Stock

Principal Investigator: Christine Mayer **Funding Total:** $435,470

This project identifies mechanistic linkages between early life history stages of important fish species and specific habitats in order to characterize habitat impairments that limit fish production in Western Lake Erie. This research helps guide management and restoration of fish populations and their habitats in the study areas; for example, it provides resource managers with early forecast information on the magnitudes of production and year-class strength for important sport and commercial fish populations such as walleye, which inhabit Lake Erie but use the Maumee River and Bay as spawning and nursery areas.

Project Title: Food Web Structure and Trophic Transfer Across Lake Erie's Productivity Gradient

Principal Investigator: Christine Mayer **Funding Total:** $94,073

This project assesses the current trophic transfer to fisheries in relation to Lake Erie's spatially-structured drivers including: West to East gradient in productivity, inshore vs. offshore gradients, and qualitative and quantitative differences between the 'Western and Central Basins. Quantifying food-web responses to these gradients is important to supporting management and restoration decisions, and to predicting how the system may

respond to future change.

Project Title: Food Web Linkages Between Nearshore and Offshore Lake Michigan (CSMI 2015)

Principal Investigator: Christine Mayer **Funding Total:** $251,688

The Maumee River mouth is a prime target for restoration efforts focused on recovery and rehabilitation of native species, habitats, and ecosystems. This project quantifies the spatial and temporal dynamics of fish spawning and larval fish ecology in the Maumee River and adjacent western Lake Erie. This research identifies linkages between early life history stages of important fish specifies and specific habitats impaired by anthropogenic activity and therefore, may be targets for restoration. Information gained from this project will be used to guide management and restoration of fish populations and their habitats in the study areas.

Project Title: Assessment of Riverine Habitat Restoration in the St. Clair-Detroit River Systems

Principal Investigator: Christine Mayer **Funding Total:** $323,375

This project analyzes and interprets existing and new data to determine efficacy and extent of use of restored habitats by fishes and other organisms. Further, data analyses and modeling will be conducted to identify mechanistic linkages between important fish species and other organisms with specific physical and biological habitat attributes. This study allows researchers to characterize habitat improvements/impairments and how they affect fish production. Information gained from this project will be used to guide management and restoration of fish populations and their habitats in the study areas.

Project Title: Hydroacoustic Determination of Distribution and Abundance of Lake Erie Walleye

Principal Investigator: Christine Mayer **Funding Total:** $224,301

The goal of this project is to better describe walleye behavior (local and lake-wide) in order to reduce uncertainty in an ongoing Ohio Department of Natural Resources-Division of Wildlife gill net survey. This approach develops a hydroacoustic sampling protocol to mirror the currently conducted ODNR annual fall gill net survey.

Project Title: Grass Carp Spawning Potential in the Sandusky River

Principal Investigator: Song Qian **Funding Total:** $105,059

This funding supports coordination of vegetation surveys in watersheds across multiple jurisdictions. It includes a provision for researchers and graduate students to travel to regional and local professional meetings and national conferences to discuss the implications of potential spawning of grass carp in Lake Erie.

Project Title: Grass Carp Spawning Potential in the Sandusky River Basin

Principal Investigator: Song Qian **Funding Total:** $100,059

With their voracious appetite, grass carp alter aquatic ecosystems and threaten native fish species. An invasive species, grass carp have no natural predators in North America and can be difficult to eradicate once established. This project focuses on identifying the spawning potential of grass carp. It is a management and conservation priority to prevent a reproducing population of grass carp from becoming established in the Great Lakes, which support a valuable fishery for native and managed species.

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