ABSTRACTS

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From Cities to Farms: SHAPING GREAT LAKES ECOSYSTEMS

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ABSTRACTS

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ABSTRACTS

An alphabetical listing of abstracts presented at the 60th Annual Conference on Great Lakes Research, organized by first author. Presenters are underlined.

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ABOUALI, M.[1], NEJADHASHEMI, A.P.[1], DANESHVAR, F.[1], ADHIKARI, U.[1], HERMAN, M.R.[1], CALAPPI, T.J.[2], and ROHN, B.G.[2], [1]Michigan State University, 524 S. Shaw Lane, East Lansing, MI, 48824, USA; [2]U.S. Army Corps of Engineers, 477 Michigan Ave., Detroit, MI, 48226, USA. **Watershed-level Evaluation of Wetland Implementation Strategies on Phosphorus Reduction.**

One of the major sources of water quality degradation is the excessive use of nutrients in agriculture, which could lead to eutrophication of freshwater resources. Meanwhile, implementation of wetlands has been proven as an effective approach for mitigating the impacts of excessive nutrients. However, to have an efficient water quality management at the watershed scale, site selection for wetland implementation is a key factor. In this study, three conventional and two pseudo-random targeting scenarios are investigated. The Soil and Water Assessment Tool (SWAT), a watershed model is coupled with Urban Stormwater Treatment and Analysis Integration (SUSTAIN) to study the impacts of wetland implementation scenarios on the Saginaw River watershed, located in Michigan. The results showed that the similarity between these targeting scenarios increases with the implementation area. The conventional method that is based on phosphorus load generated per unit area at the subwatershed scale, on average, performed better. However, considering the total area of the implemented wetlands, another conventional method based on the long-term impacts of the wetland had better performance. In all cases, the climate impact was the major factor affecting the wetland performance. *Keywords: Watersheds, SWAT, Wetlands, SUSTAIN, Phosphorus.*

ADAMS, J.M.[1], CHERWATY-PERGENTILE, S.[2], MEYER, K.[3], STADLER-SALT, N.[2], and TEPAS, K.M.[4], [1]U.S. Environmental Protection Agency, 77 W. Jackson Blvd, G-17J, Chicago, IL, 60604, USA; [2]Environment and Climate Change Canada, 867 Lakeshore Rd, Burlington, ON, L7R4A6, CANADA; [3]ORISE Fellow, 77 W. Jackson Blvd, G-17J, Chicago, IL, 60604, USA; [4]Illinois-Indiana Sea Grant, 77 W. Jackson Blvd., G-17J, Chicago, IL, 60604, USA. **Overview of the State of the Great Lakes: Status and Trends.**

The Great Lakes are a vast shared resource and are fundamental to the well-being of over 40 million Canadians and Americans who live along their shores. Despite their immense size, the Great Lakes are highly sensitive to stresses including the impacts of climate change, invasive species and toxic contaminants. So, how are the Great Lakes doing? The Science Annex of the 2012 Great Lakes Water Quality Agreement commits the Governments of Canada and the United States to assess the Great Lakes ecosystem using a suite of comprehensive, science-based indicators and to answer this very important question. There are 9 indicators used to measure progress towards achieving the 9 General Objectives of the Agreement. In this presentation, an overview of the current State of the Great Lakes will be provided. This overview is derived from 44 sub-indicator reports which feed into the 9 indicators that were prepared for the 2016 State of the Great Lakes Technical Report as well as the presentation that was given at the 2016 Great Lakes Public Forum. The governments also use this information to issue State of the Great Lakes Highlights and Technical reports every three years to describe the conditions and trends of the ecosystem.
Keywords: SOLEC, Great Lakes basin, State of the Great Lakes, Indicators, Monitoring, Great Lakes Indicators.

ADEN, S.T.[1], VERHAMME, E.M.[2], BROOKS, C.N.[1], and SULLIVAN, J.[3], [1]Michigan Tech Research Institute, Ann Arbor, MI, USA; [2]LimnoTech, Ann Arbor, MI, USA; [3]Aerial Associates, Ann Arbor, MI, USA. **Monitoring Thermal Discharge from Power Generating Facilities in the Great Lakes.**

Michigan Tech Research Institute and LimnoTech conducted seasonal surveys of thermal discharge from select power generating facilities across the Great Lakes in 2016. A Flir Vue Pro camera was flown from manned and unmanned aerial platforms over active power plants' outflow channels to detect the extent and severity of changes in the lake surface temperature. Power plants surveyed include facilities in Lake Superior and Lake Huron. Aerial imagery was supplemented by in-situ point-sampled data from coincident cruises and cloud-free Landsat 8 satellite imagery for the purpose of comparing and validating the thermal remote sensing techniques. The goal of this research is to develop and compare methodologies for imaging plumes. The aerial surveys were able to capture relative heat profiles of the lake surface, which could then be radiometrically calibrated according to in-situ measurements, and compared with relevant satellite data. Progress was also made with resolving true surface temperature values from our non-radiometric thermal camera.

AL-DABBAGH, O., KRANTZBERG, G., and GROVER, V.I., McMaster University, 1280 Main Street West, Hamilton, ON, L8S 4L8, CANADA. **Phosphorus and Nitrogen as Large-Scale Stressors in the Great Lakes.**

The emphasis on phosphorus (P) reduction strategies in the Great Lakes has been built on its presumed primary role in limiting the growth of aquatic flora biomass. This assumption was justified by some reasons that are: 1) removal processes of P from polluting sources are easier compared to nitrogen (N), 2) some cyanobacteria capable of fixing N_2 are thought to make N reduction infeasible, and 3) the correlation between total P (TP) and chlorophyll is stronger than total N (TN). These reasons have been reviewed by other studies that demonstrated weaknesses in their cogency The question we address is: Why are the lower Great Lakes continuing to see harmful algal blooms despite P load reductions? Our research is looking at the effectiveness of P management compared to the effectiveness of the N and P co-management in large lakes. *Keywords: Environmental policy, Phosphorus and Nitrogen Nutrient Reduction Co-management, Policy making, Eutrophication.*

ALIGHALEHBABAKHANI, F.[1], MILLER, C.J.[1], and SELEGEAN, J.P.[2], [1]Wayne State University, 5050 Anthony Wayne Drive, Detroit, MI, 48105, USA; [2]U.S. Army Corps of Engineers, Detroit District, Detroit, MI, 48226, USA. **Impacts of land use change and dam construction on sediment delivery to the Laurentian Great Lakes.**

Human interfere since European settlement, including land use change and dam construction can alter sediment delivery to downstream reaches. The purpose of the present research is to measure the sediment delivery changed to the Great Lakes because of human impacts. To better evaluate the historical and current sediment yield, Soil and Water Assessment Tool (SWAT) were applied. The SWAT models of eleven sub-watersheds within the Great Lakes Basin were developed as a case study. In the next step, a regression analysis was completed on the results of the eleven SWAT models to predict the current and historical sediment yield in un-modeled watersheds. Extrapolating the results of SWAT models across the Great Lakes Basin approved that the sediment delivery to each lake has increased by an order of magnitude since European settlement. The dam construction on the rivers reduces sediment delivery due to trapping sediment load within the reservoir. However, land use change since European settlement increased sediment delivery across the Great Lakes Basin. Since European settlement, the forests were cleared to expand agricultural activity and urban area, which are the source of inducing soil erosion.
Keywords: Sediment load, Great Lakes basin, Modeling.

ALLAN, J.D., MANNING, N.F., SMITH, S.P.D., DICKINSON, C., and JOSEPH, C., University of Michigan SNRE, 440 Church St., Ann Arbor, MI, 48109, USA. **Ecosystem Services of Lake Erie: Spatial Distribution and Concordance of Multiple Services.**

The Laurentian Great Lakes provide a wide range of ecosystem services (ES), but incorporation into environmental planning has been limited due the lack of detailed information on the spatial distribution and extent of ES delivery. We mapped the spatial distribution of 12 ES including 3 supporting, 3 provisioning and 6 recreational/cultural services for both coarse and fine scales of analysis. Whether ES are quantified by presence-absence or service delivery, the mix of services varies among locations. Some ES were found to be spatially correlated due to common function, such as sport fishing, boat launches and marinas, and some ES were co-located according to shared 'human habitat', as seen with municipal parks and municipal water supply, both in or near urban centers. Most ES were spatially uncorrelated and significant associations were almost exclusively positive, indicating that trade-offs were not evident for the 12 ES examined. Total service delivery varied significantly among locations county and focal area scales, indicating that service hotspots and cold spots were common. Managers may benefit from awareness of the extent of ES delivery for different services in their area of interest, but we found little evidence that co-benefits or trade-offs would influence management decisions for the services we examined. *Keywords: Management, Ecosystem Services, Lake Erie.*

ALLEN, B.A. and MANDRAK, N.E., University of Toronto Scarborough, 1265 Military Trail, Toronto, ON, M1C 1A4, CANADA. **Effects of Multiple Stressors on the Fish Communities of the Credit River Watershed.**

Watersheds in southern Ontario are of high conservation concern due to their diverse fish communities, productive environments, and threats from various anthropogenic stressors (Chu et al. 2015). The Credit River watershed, just west of Toronto, has 60 fish species and multiple stressors, including urbanization, climate change, and aquatic invasive species (AIS), which have crept up the watershed in the last 75 years. This research examines fish community change in the Credit River watershed in relation to multiple stressors. Historical fish datasets collected in the watershed from 1954 to present were analyzed to examine patterns of fish community change and homogenization at site and subwatershed level. Stressor data consists of historical climate data, population censuses, road-density layers, and AIS. The results will be used to better understand the interactive effects of multiple stressors in freshwater ecosystems and to provide insight into more effective watershed management. *Keywords: Credit River, Homogenization, Watersheds, Multiple Stressors, Fish.*

ALLIS, J.[1] and BRUXER, J.K.[2], [1]U.S. Army Corps of Engineers Detroit District Office of Great Lakes Hydraulics and Hydrology, Detroit, MI, MI, USA; [2]Environment and Climate Change Canada Great Lakes-St. Lawrence Reg Office, Cornwall, ON, CANADA. **Great Lakes Water Management 101.**

Development of hydrological models and datasets that are appropriate for simulation and prediction in the Great Lakes basin begins with building an understanding of the unique nature of water management in the basin. We will open this session on development of models and data for application to Great Lakes regional water management by providing the Great Lakes water managers' views on: (1) How are Great Lakes water management decisions made, (2) what organizational infrastructure exists to build, coordinate, and maintain basin-scale hydrometeorological data, and (3) what are the hydrometeorological uncertainties that pose unique challenges to Great Lakes regulation? *Keywords: Decision making, Great Lakes basin.*

ALMEIDA, L.Z.[1], SCHARNWEBER, K.[2], EKLÖV, P.[2], and HÖÖK, T.O.[1], [1]Department of Forestry and Natural Resources, Purdue University, 195 Marsteller St., Lafayette, IN, 47907, USA; [2]Department of Ecology and Genetics, Uppsala University, Norbyvägen 18d, Uppsala, SWEDEN. **Using morphology and trophic markers to indicate fish niche use in seasonally hypoxic lakes.**

Hypolimnetic seasonal hypoxia develops in a variety of lentic systems - from small lakes to the Laurentian Great Lakes - and may limit fish's access to a niche with energy-rich prey. Recent studies in the Great Lakes and other systems demonstrate that diet and habitat specialization is quite common for fishes and can lead to morphological divergence among habitats. We explored if late summer reduction of oxygen in the hypolimnetic zone influenced morphological, fatty acid, and stable isotope divergence between Eurasian perch (*Perca fluviatilis*) from littoral and pelagic habitats in Swedish lakes. We hypothesized that the elimination or reduction of the profundal/hypoxic zone would decrease divergence between fish as seasonal elimination of habitat could increase habitat and trophic overlap. Preliminary analyses suggest that littoral and pelagic perch diverged trophically and morphologically to varying degrees in each lake; however, divergence did not appear to be related to the hypoxic status of each lake. This may be because the duration and extent of hypoxic conditions were not great enough to significantly alter habitat occupancy and feeding habits of perch. *Keywords: Niches, Trophic level, Eutrophication.*

ALOYSIUS, N., MARTIN, J., LUDSIN, S.A., KALCIC, M.M., KAST, J.B., and APOSTEL, A.M., Ohio State University, 590 Woody Hayes Dr, Columbus, OH, 43210, USA. **Drivers of nutrient hotspots in agriculturally dominated watersheds.**

Human-driven changes in land management, and increasing precipitation and frequency of heavy storms have been identified as key drivers that exacerbate nutrient leakage from watersheds. While total nutrient delivery to downstream ecosystems and its variability are well-studied, the spatiotemporal dynamics within the contributing watersheds have not been adequately investigated. To address this knowledge gap, we used a hydrological model of Lake Erie's largest watershed and statistical analyses to examine linkages between changes in nutrient leakage dynamics, and spatiotemporal variability in precipitation and watershed management practices. With the validation of model simulations at multiple locations within the watershed, we are able to capture and describe the seasonal, inter-annual and spatial variability of nutrient fluxes. Findings indicate that areas with poorly drained soils respond fast and contribute greater proportions of nutrient fluxes through multiple flow pathways. Our work highlights the likely need for changes in land management to counteract anticipated climate change effects in ecosystems dominated by agriculture and offers a readily adoptable approach to forecast climate change impacts on nutrient leakage to downstream ecosystems. *Keywords: Phosphorus, Hydrologic cycle, Agriculture, Nutrients, Climatology.*

ALSIP, P.[1], RICE, N.[2], IOTT, S.[1], STURTEVANT, R.A.[3], MARTINEZ, F.[4], and RUTHERFORD, E.[2], [1]Cooperative Institute for Limnology and Ecosystems Research, 4840 South State Road, Ann Arbor, MI, 48108, USA; [2]NOAA Great Lakes Environmental Research Laboratory, 4840 South State Road, Ann Arbor, MI, 48108, USA; [3]Great Lakes Sea Grant Network, 4840 South State Road, Ann Arbor, MI, 48108, USA; [4]NOAA NCCOS, 4840 South State Road, Ann Arbor, MI, 48108, USA. **The Great Lakes Aquatic Nonindigenous Species Information System Watchlist.**

The Laurentian Great Lakes is one of the most heavily invaded aquatic systems in the world with over 180 documented aquatic nonindigenous species, the peak invasion rate was estimated to be 2.8 species introduced per year (1990-1995). While invasion rates have slowed in recent years, prevention remains the best defense. The Great Lakes Aquatic Nonindigenous Species Information System (GLANSIS) currently serves information for 67 species which have been identified through the peer-reviewed scientific literature as having some likelihood of invading the Great Lakes. This poster was developed primarily as an outreach tool to help scientists and citizens know what to look for in monitoring for the presence of these species. Monitoring is essential both to determine the success of prevention programs and to support early detection - early enough to make true rapid response and eradication feasible. The poster links back to the GLANSIS database, which includes further information about the potential for introduction, establishment, and impact of these species as well as more detailed information on how to identify the species and information on management options in the event they are detected. *Keywords: Biological invasions, Invasive species, Species composition.*

AMERI, S.[1], GILBERT, J.M.[2], and CHOW-FRASER, P.[1], [1]McMaster University, 1280 Main Street West, Hamilton, ON, L8S4K1, CANADA; [2]Private Consultant, Langton, ON, L8S4K1, CANADA. **Effectiveness Monitoring of a Control Program for Invasive Phragmites in Rondeau Bay Wetland Complex.**

The Rondeau Bay Provincial Wetland complex supports high native biodiversity, including many species of plants, fish, birds and reptiles. Like many other wetlands in southern Ontario, Rondeau Bay has been negatively affected by the growth of invasive *Phragmites australis*, which has reduced access to breeding, foraging and overwintering habitats for several species of at-risk reptiles. Between 2010 and 2014, a program consisting of rolling, burning and glyphosate application has been used to control Phragmites stands throughout Rondeau Provincial Park. Here, we use digitized spring-time orthophotos (0.2 m resolution) from the Southwestern Orthophotography Project (SWOOP) acquired during 2010 and 2015 to assess the effectiveness of the treatment program within the Park. We found that patches of Phragmites had been reduced in size by more than 75% from 2010 to 2015, compared with control patches of similar size that had not been treated. Additional analyses will be carried out to determine if repeat treatment with glyphosate in consecutive or subsequent years can result in higher efficacy. Effectiveness monitoring using remote sensing can provide more comprehensive coverage than can be achieved through field surveys alone, and is very cost effective when image data such as SWOOP are used. *Keywords: Phragmites australis, Remediation, Remote sensing.*

ANDERSON, E.J.[1], LANG, G.A.[1], CHU, P.[1], FUJISAKI-MANOME, A.[2], and WANG, J.[1], [1]NOAA/GLERL, 4840 S. State Rd, Ann Arbor, MI, 48108, USA; [2]University of Michigan, CILER, 4840 S. State Rd, Ann Arbor, MI, 48108, USA. **Development of the Next-Generation Lake Michigan-Huron Operational Forecast System (LMHOFS).**

The next-generation NOAA Great Lakes Operational Forecast System (GLOFS) is under development with the Finite Volume Community Ocean Model (FVCOM). The first generation GLOFS, based on the Princeton Ocean Model (POM), became operational in 2004, providing nowcasts and forecasts of hydrodynamic conditions for each of the Great Lakes using a structured grid with resolutions of 5 and 10k. In the next-generation GLOFS, Lakes Michigan and Huron are combined into a single system with horizontal resolution that ranges from 200m coastlines to 2.5km offshore. Similar to the new NOAA Lake Erie Operational Forecast System (LEOFS), the LMHOFS will use hydrologic inputs to enable lake-level tracking of the hydrologic cycle and include the FVCOM-Ice module. Hindcast simulations of 2014-2016 have been carried out using both the first-generation methodology of interpolated meteorological conditions and the next-generation atmospheric forcing from the High-Resolution Rapid Refresh (HRRR). Results show the next-generation model improves simulation of thermal structure in the lakes as well extends operational capability for ice and hydrologic coupling. *Keywords: Hydrodynamic model, Lake Michigan, Lake Huron.*

ANDERSON, E.J.[1], BECHLE, A.J.[2], WU, C.H.[2], CHU, P.[1], MANN, G.E.[3], SCHWAB, D.J.[4], and LOMBARDY, K.[5], [1]NOAA/GLERL, 4840 S. State Rd, Ann Arbor, MI, 48104, USA; [2]University of Wisconsin-Madison, Madison, WI, USA; [3]NWS WFO-Detroit, Detroit, MI, USA; [4]University of Michigan, Water Center, Ann Arbor, MI, USA; [5]NWS WFO-Cleveland, Cleveland, OH, USA. **Investigation into Recent Meteotsunami Events in the Great Lakes.**

Meteotsunami events have been documented in several countries around the world in the coastal ocean, semi-enclosed basins, and in the Great Lakes. In particular, investigations in the Great Lakes have raised the issue of dangers posed by enclosed basins due to the reflection and interaction of meteotsunami waves, in which the destructive waves can arrive several hours after the atmospheric disturbance has passed. This disassociation in time and space between the atmospheric disturbance and resultant meteotsunami wave can pose a significant threat to the public. In recent events in the Great Lakes, atmospheric conditions have induced meteotsunami waves in Lake Erie and Lake Superior. The resulting waves impacted swimmers, inundated a marina, flooded coastal communities. In this work, we attempt to explain the processes that led to these conditions through a combination of atmospheric and hydrodynamic modeling and an analysis of the observed meteorology. Results from a high-resolution atmospheric model and hydrodynamic model reveal the formation of destructive waves resulted from a combination of wave reflection, focusing, and edge waves, though important differences have been found between recent events in the Great Lakes. *Keywords: Waves, Meteotsunami, Hydrodynamics.*

ANDERSON, M.R., PAVER, S.F., VARGAS, J.G., PODOWSKI, J.C., WATSON, A.R., BYL, P.K., WASNEY, M.W., and COLEMAN, M.L., University of Chicago, Chicago, IL, USA. **Genomic insights into the phylogeny and metabolism of novel bacterial taxa from the Great Lakes.**

Despite the recognized importance of microorganisms to Great Lake ecosystems, which organisms are present and what they are doing to respond to and shape lake biogeochemistry remains largely unknown. We analyzed information contained in microbial genomes to provide insights into the microbial ecology of the Great Lakes. Community genomic DNA was sequenced from surface samples collected from each of the five

Laurentian Great Lakes during Spring 2012. Putative genomes, referred to as Metagenome Assembled Genomes (MAGs), were reconstructed from co-assemblies of the resulting metagenomes. Novel putative genomes with high completeness based on the presence of single copy core genes included MAGs identified (or most similar) to the following described phyla: *Gemmatimonadetes*, *Ignavibacteriae*, *Kryptonia*, *Nitrospirae*, *Planctomycetes*, *Verrucomicrobia*. We present the phylogeny, inferred metabolism, and ecology of previously undescribed Great Lakes taxa based on genome sequence data, representation in metagenomes from each lake, and distribution in a 16S rRNA gene survey of Great Lakes samples collected from ~3 stations per lake, 3-4 depths per station, following ice-off in the Spring and again in August over 4 years. Genomic insights offer clues into the processes shaping Great Lakes ecosystems. *Keywords: Microbiological studies, Biogeochemistry, Genetics.*

ANGRADI, T.R.[1] and LAUNSPACH, J.J.[2], [1]United States Environmental Protection Agency, 6201 Congdon Blvd, Duluth, MN, 55804, USA; [2]SRA International Inc., 6201 Congdon Blvd, Duluth, MN, 55804, USA. **Crowd-sourcing Relative Preferences for Ecosystem Services in a Great Lakes AOC.**

Analysis of ecosystem service tradeoffs among AOC project scenarios is more reliable if valuation data are available. As an alternative to empirical data, we classified images from social media sites (SMS) Panoramio (n= 638), Instagram (n=2085), and Flickr (n=6643) for the St. Louis River AOC and a 100 m riparian buffer. We classified each image from the perspective of the photographer (beneficiary) using US EPA's Final Ecosystem Goods and Services Classification System (FEGS-CS). After removing images not in the AOC, 65 (12%), 361 (24%), and 1035 (16%) of the images from Panoramio, Instagram, and Flickr, respectively, depicted an ecosystem service. The most frequently occurring non-ecosystem services depicted were indoor scenes, people outdoors not experiencing nature, bridges, and ships. Across SMS with repeated images removed, AOC-based recreational services were percentage ranked as follows: natural scene viewing/artistic inspiration, 31%; boating (sailing, powered, and human-powered), 24%, birding, 15%; fauna and flora viewing, 8%; trail and greenspace use, 7%; angling (shore, boat, and ice), 7%; dog walking, 3%; swimming, beach and ice use, 2%; biking, 1%; excursion rail, 1%. Non-recreational services of learning, sacred/inspiration, and commercial fishing were depicted in <2% of images. Potential biases are discussed. *Keywords: St. Louis River AOC, Crowd-sourcing, Citizen science, Ecosystem services.*

ANNEVILLE, O.[1], DUR, G.[2], RIMET, F.[1], CHANG, C.W.[3], HSIEH, C.H.[3], and SOUISSI, S.[4], [1]INRA UMR CARRTEL, Thonon les Bains, FRANCE; [2]2- Creative Science course (Geosciences), Faculty of Science, Shizuoka University, Shizuoka, JAPAN; [3]3- Research

Center for Environmental Changes, Academia Sinica, Taipei, TAIWAN; [4]4- Université de Lille, CNRS, Université du Littoral Côte d'Opale, UMR 8187, LOG, Wimereux, FRANCE. **Reducing phytoplankton diversity to understand ecosystem functioning: The Baroque in the Nature.**

Climate changes and local management policies have important implications for aquatic ecosystems. Total phytoplankton biomass is often used as a measure of ecosystem functioning. Variability in total phytoplankton biomass results from internal processes associated with biodiversity that may have a stabilizing effect at the community level and can buffer the impacts of environmental changes. As a consequence the estimated sensibility of ecosystems to environmental changes might be underestimated. Because of the high diversity of phytoplankton species, analyzing the temporal variability of each species might be difficult. To overcome this problem, one solution involves focusing on the dominant or keystone species. Pooling species into groups having similar characteristics based on phylogenetic, morphological and/or functional features usually appears as a good alternative. Here we propose another alternative based on the pattern of the species occurrence. We used long-term datasets to identify species assemblages in Lake Geneva. Using a Bayesian approach, we computed occurrence probabilities of each phytoplankton assemblages to analyze their pattern of succession at the seasonal and inter-annual scales. Results show a clear seasonal pattern that presents inter-annual variability in response to top-down and bottom-up controls. *Keywords: Biodiversity, Phytoplankton, Ecosystems.*

ANNIS, G.[1], MAY, C.A.[1], PEARSALL, D.[1], KAHL, K.J.[1], CHOW, M.A.[2], and FERDANA, Z.A.[2], [1]The Nature Conservancy, Lansing, MI, USA; [2]The Nature Conservancy, Seattle, WA, USA. **Informing Coastal Resilience in Western Lake Erie: A New Visualization Tool on CoastalResilience.org.**

The western Lake Erie basin (WLEB) is ecologically and culturally important, providing world-renowned fishing and migratory bird-watching opportunities that contribute substantial economic revenues to the region. Despite these assets, the WLEB has been severely degraded by multiple stressors, and only 5% of the original 307,000 acres of coastal wetlands remain. Within the context of climate change, and unlike sea levels, water levels in the Great Lakes are not predicted to rise. However, the magnitude of natural lake-level fluctuations is predicted to increase and extreme high lake levels could exacerbate storm and flood damage, especially at river mouths. Using the Natural Solutions Toolkit, we have developed a stakeholder-driven, web-based geospatial platform on CoastalResilience.org to put science-based information into the hands of community decision makers and conservation practitioners. This platform will allow planners to visualize flood scenarios at various lake levels, estimate economic loss and infrastructure damage, and plan for hazard

mitigation through restoration, policy and planning actions that complement economic development, place making and other competing priorities. *Keywords: Water level fluctuations, Decision making, Coastal ecosystems.*

APOSTEL, A.M.[1], KALCIC, M.M.[1], MUENICH, R.L.[2], TESHAGER, A.D.[2], MARTIN, J.[1], and SCAVIA, D.[2], [1]Department of Food, Agricultural and Biological Engineering, Ohio State University, Columbus, OH, 43210, USA; [2]Water Center, Graham Sustainability Institute , University of Michigan, Ann Arbor, MI, 48103, USA. **Simulating historical land management impacts on Maumee River phosphorus loading trends.**

The return of algal blooms to the Western Basin of Lake Erie have focused management strategies on reducing phosphorus loading. While there has been a clear increase in the loading of dissolved reactive phosphorus (DRP)--suspected to be the primary culprit responsible for the recurrence and severity of these blooms--there is less certainty about which land management factors were responsible for this trend. Understanding and simulating historical changes in land management techniques can shed light on the cause of elevated DRP loading. We are using a recalibrated and spatially refined model of the Maumee River watershed, developed within the Soil and Water Assessment Tool, to investigate changes in historical land management over the past 30 years to identify those factors which have played the most pivotal role in the DRP increases. We argue that a better understanding of the water quality impacts of past land management enables models to more accurately assess the impacts of potential management changes and can inform future management strategies. *Keywords: Lake Erie, Phosphorus, Management.*

APPS, D.C. and FRY, L.M., United States Army Corps of Engineers, 477 Michigan Ave., Detroit, MI, 48226, USA. **Developing and Testing New Regression Models for Application to Seasonal Water Level Forecasts.**

Multiple linear regression models relating observed and predicted precipitation and temperature to Net Basin Supply serve as one cornerstone to USACE seasonal water level forecasts. While these models have some skill, advancements in observational and modeled hydrometeorological data as well as alternative seasonal climate projections since the development of these regression models, offer an opportunity for improvement. The first component of this study evaluates the potential for improving the existing USACE regression model using ensemble climate model forecasts of temperature and precipitation to better reflect uncertainty. The second aspect of this research explores the utility of incorporating additional water budget variables to enhance the skill of the regression model. This presentation highlights each of these experiments with the aim of guiding future improvements to seasonal water budget forecasting. *Keywords: Model studies, Regression model, Water level.*

ARIF, A. and WELLS, M.G., University of Toronto Scarborough, 1095 Military Trail, DPES, University of Toronto, Toronto, ON, M1C1A4, CANADA. **Evaluating the potential effects of benthic currents in Lake Ontario upon an energy storage facility.**

Underwater compressed air energy storage (UWCAES) is an innovative new technology, which addresses intermittent energy storage to enable the use of renewable energy sources. An UWCAES and pressurized air accumulators approximately the height of a three-story building, have been installed 80 meters underwater several kilometers offhore from Toronto Harbour in Lake Ontario. Very little research has occurred at the depths at which this infrastructure is located and this poster will review the existing literature on benthic currents in the Great Lakes, and describe a field deployment occurring in 2017. The bathymetry offshore of Toronto Harbour has a large underwater escarpment and so it is possible along-shore benthic currents may intensify in this location compared to previous deployments at similar depths in other Great Lakes. We will discuss the likely impacts of these generally weak currents on the operation of renewable energy infrastructure installed offshore. *Keywords: Benthos, Lake Ontario, Water currents.*

ASTIFAN, B.[1], NOEL, J.[1], and STUMPF, R.P.[2], [1]NOAA/NWS Ohio River Forecast Center, Wilmington, OH, USA; [2]NOAA National Ocean Service, Silver Spring, MD, USA. **Use of Climate Forecasting System Forcings to Improve Lake Erie Harmful Algal Bloom Bulletin.**

The National Ocean Service and National Weather Service are using an ensemble of hydrologic model output forced by the National Center for Environmental Prediction (NCEP) Climate Forecast System (CFS) in a pilot project to improve estimates of nutrient loading from the Maumee River into the western Lake Erie basin. Following the 2014 bloom that impacted drinking water in the City of Toledo, NOS started an experimental bulletin of expected seasonal Lake Erie cyanobacterial bloom severity in May 2015. The projections made from May into early June presumed normal flows from the Maumee River, and called for an average bloom severity. Actual flows were well above seasonal norms during June and July, resulting in a underestimation of HAB severity that was not captured until the outlook issued in early July. Following the 2015 event, hindcasting of the Maumee River Basin using a CFS technique developed by OHRFC showed skill in identifying the unseasonable flow event. CFS-based estimates are now generated for the Waterville, Ohio gage daily by OHRFC, and were used by NOS in the spring of 2016 to generate the seasonal bloom outlooks. The 2016 outlook of below normal cyanobacteria risk verified, as below normal

rainfall during the critical runoff period in the spring was accurately captured. *Keywords: Lake Erie, Harmful algal blooms.*

AUDETTE, Y.[1], O'HALLORAN, I.P.[2], NOWELL, P.M.[1], and VORONEY, R.P.[1], [1]School of Environmental Sciences, University of Guelph, Guelph, ON, N1G2W1, CANADA; [2]School of Environmental Sciences, University of Guelph, Ridgetown, ON, N0P2C0, CANADA. **An understanding of legacy P in sediments - chemistry of P forms influenced by agricultural practice.**

The goal of this research was to identify legacy P forms found in stream sediments of the West Holland subwatershed, including the sediments of the agriculturally impacted West Holland River. Sediment core samples were collected in November 2015 and sediment P forms were characterized and quantified by sequential fractionation and solution 31-P NMR spectroscopy techniques. The dominant bedrock in the study area is calcite. The major sediment P form at sites exhibiting a low risk of P release was stable Ca-bound P. In contrast, the major form of sediment-P at sites exhibiting a high risk of P release was redox-sensitive P, despite higher concentrations of Ca in surface waters at these sites. Sites exhibiting a high risk of P release also had higher organic matter (OM) contents. This OM may complex with Fe and adsorb P. The resulting OM-Fe complexes may inhibit the formation of stable Ca-P minerals. Agricultural fertility practices increased loosely bound inorganic P in sediments, while organic P accounted for a higher proportion of total P in surface sediments than in deeper sediments, suggesting that bioavailable inorganic P is immobilized by phytoplankton and bacteria upon entering the water column and returned to sediments as decaying biomass settles. *Keywords: Phosphorus, Lake Simcoe, Sediments.*

AUER, M.T. and KUCZYNSKI, A., Michigan Technological University and Great Lakes Research Center, 1400 Townsend Dr., Houghton, MI, 49931, USA. **Setting Phosphorus Substance Objectives for *Cladophora* Management.**

The filamentous green alga *Cladophora* has impaired water quality in the Laurentian Great Lakes for decades, fouling beaches, clogging water intakes, and lowering property values. The Great Lakes Water Quality Protocol of 2012 explicitly states as one of its Annex 4 (Nutrients) Lake Ecosystem Objectives that the Parties to the Agreement must "maintain the levels of algal biomass below the level constituting a nuisance condition." Yet, after decades of degradation of nearshore water quality and the mandate provided by the 2012 Protocol, no Lake Ecosystem Objectives are in place defining acceptable levels of biomass densities and no Substance Objectives are in place quantifying phosphorus levels required to eliminate nuisance conditions. In this work, we 1) review published records of observed biomass densities to quantitatively represent nuisance conditions, 2) apply the Great Lakes

Cladophora Model v3 (GLCM v3) to determine acceptable bioavailable phosphorus concentrations for controlling *Cladophora* growth, and 3) examine those concentrations in the context of tributary and point source loads presently contributing to nuisance growth. *Keywords: Cladophora, Phosphorus, Management.*

AUSTIN, J.A., University of Minnesota Duluth, LLO, Duluth, MN, 55812, USA. **Preliminary Measurements of Passive Acoustics in Lake Superior.**

In July 2016, a hydrophone was deployed for eight days in 54m of water in the western arm of Lake Superior. This is, to the best of our knowledge, the first recording of passive acoustic information in a large lake. The signal is dominated by noise from passing ships (30-100Hz) and by surface winds (broad spectrum). Noise from passing ships drops off as approximately r^{-6}, suggesting that there are significant transmission losses associated with reflections off of the bottom. The signal associated with wind is highly correlated with wind speed as measured at a nearby buoy. Intermittent "clicks" look similar to burbot calls previously observed, and appear to occur only in the absence of ship noise. This suggests a potential behavioral response to ambient acoustic energy. Ray tracing experiments suggest the acoustic environment within the lake will change drastically as the lake transitions from summer stratified conditions to unstratified, and again when inverse winter stratification sets in. *Keywords: Acoustics, Lake Superior, Measuring instruments.*

AVLIJAS, S.[1], MANDRAK, N.E.[2], and RICCIARDI, T.[1], [1]McGill University, Montreal, QC, CANADA; [2]University of Toronto Scarborough, Toronto, ON, CANADA. **The Eurasian Tench (*Tinca tinca*): A globally invasive fish poised to invade the Great Lakes.**

The Great Lakes are likely to be invaded soon by Tench (*Tinca tinca*), a Eurasian cyprinid fish illegally introduced to Quebec in 1986 and released in the Richelieu River in 1991. Within two decades after its release in the Richelieu River, Tench expanded to Lake Champlain and to the St. Lawrence River from Quebec City to Lake St. Francis. In September 2017, it was detected in the Ontario waters of Lake St. Francis, a fluvial lake on the St. Lawrence River, 200 km downstream from Lake Ontario. In another fluvial lake, Lake St. Pierre, immediately downstream of the Richelieu River inflow, Tench abundance has been increasing exponentially since 2011. The recent high rates of dispersal and population expansion of Tench raise concerns about the potential ecological consequences of an impending invasion of the Great Lakes basin. The Tench has established in a broad range of habitats worldwide, with populations on every continent except Antarctica, but its local densities and impacts are highly variable. We review the invasion history of Tench and assess the risks it poses based on current knowledge. Finally, we offer life-history information and advice for effective early detection and management. *Keywords: Exotic species, St. Lawrence River, Fish.*

B

BADE, A.B.[1], VANDERGOOT, C.S.[2], BINDER, T.R.[3], FAUST, M.D.[4], HARTMAN, T.J.[4], KRAUS, R.T.[2], KRUEGER, C.C.[3], and LUDSIN, S.A.[1], [1]The Ohio State University, 1314 Kinnear Road, Columbus, OH, 43212, USA; [2]United State Geological Survey, 6100 Columbus Avenue, Sandusky, OH, 44870, USA; [3]Michigan State University, 11188 Ray Road, Millersburg, MI, 49759, USA; [4]Ohio Department of Natural Resources, 105 W Shoreline Drive, Sandusky, OH, 44870, USA. **Using Knowledge of Sex-Specific Reproductive Behavior to Inform the Management of Lake Erie Walleye.**

Lake Erie's walleye fisheries are supported by numerous local spawning populations. Variability in reproductive success among these populations, especially the open-lake reef complex in western Lake Erie, is believed to drive variability in recruitment to the adult population and fisheries it supports. One way that reproductive success could be hindered is through exploitation, especially if fertile adults are harvested before spawning. To this end, closure of the reefs to fishing during the spawning season has been suggested. Herein, we combine acoustic telemetry, in situ egg collections, and creel surveys to test hypotheses concerning sex-specific differences in walleye reproductive behavior on the reef complex, with the goal of learning how these differences influence vulnerability to exploitation. While temperature appeared to drive the initiation of spawning for both sexes, sexually dimorphic behavior patterns were evident. Our telemetry and creel data show that male walleye arrive earlier and remain on the reefs longer than females, who stage on the periphery and enter for a short duration. Given that females are an important driver of walleye population dynamics, their low vulnerability to angling indicates that the suggested closures of the reef complex to protect females are unlikely to benefit future recruitment. *Keywords: Lake Erie, Walleye, Fish behavior.*

BADE, D.L., Kent State Univeristy, Kent, OH, 44240, USA. **Microcystin Dynamics in Lake Erie Linked to Nutrients Concentrations.**

Microcystin has been a primary concern related to harmful algal blooms in Lake Erie. While high cyanobacterial biomass is often recognized to be associated with the presence of toxin, the relationship is not always straightforward. Considering the previously describe links between nitrogen status and microcystin gene regulation I hypothesized that the nitrogen form and concentration might determine toxicity. Using data collected by the Ohio

Environmental Protection Agency at 25 sites in Western Lake Erie between 2011 and 2015, microcystin concentrations were compared with nutrient concentrations to explore possible relationships. This data set, which contains nearly 350 observations, confirmed the basic relationship between algal biomass (as Chlorophyll a) and microcystin concentration (Pearson's $r = 0.67$, $p < 0.001$). Microcystin was only present when ammonium was below analytical detection levels, except in a very small subset of samples. The highest microcystin concentrations were observed when ammonium was absent and nitrate was still detectable. While microcystin could still be found after nitrate was reduced to below detection, it was generally decreasing in concentration after the disappearance of nitrate. The maximum concentration of nitrate or phosphate at a site explained much of the variation in microcystin. *Keywords: Microcystis, Nutrients, Eutrophication.*

BAILEY, K.N.[1], FULLARD, C.T.[2], STOCKDILL, D.[3], WITTEVEEN, A.[4], MARSEE, T.D.[1], LANGELAND, G.D.[1], DAMM, M.[5], and SOWDER, H.G.[5], [1]Michigan Sea Grant, Ann Arbor, MI, USA; [2]U.S. Bureau of Rclamation, Denver, CO, USA; [3]University of Michigan - School of Education, Ann Arbor, MI, USA; [4]University of Edinburgh, Edinburgh, SCOTLAND; [5]University of Michigan - College of Engineering, Ann Arbor, MI, USA. **Climate Impacts on Water Quality in the Great Lakes - A Timeline for Harmful Algal Blooms.**

An interdisciplinary team of researchers and outreach professionals investigated feedbacks between climate, land-use and the water quality and ecological health of Lake Erie. A primary component of the project was outreach and education to increase science-based understanding and decision-making by using real data and locally relevant topics for K-12 students. Our project broadened participation through inquiry-based study throughout the southeastern Michigan area focusing on climate and land-use drivers of harmful algal blooms in Lake Erie. We developed a suite of educational materials that can be used to integrate into K-12 classrooms, including a five-part curriculum, supplementary videos, and a professional development unit. Through the project we identified the need for a comprehensive timeline explaining harmful algal bloom information. We developed and published a Lake Erie HABs timeline poster as well as an online timeline which can be updated with new information. *Keywords: Lake Erie, Harmful algal blooms, Outreach.*

BAJRACHARYA, A. and LENHART, J.J., The Ohio State University, 2070 Neil Avenue, Columbus, OH, 43210, USA. **Removal of Microcystin-LR Using Powdered Activated Carbon.**

Cyanotoxins, which are released during cyanobacteria blooms, are not only an ecological concern but also a serious health issue. Powered activated carbon (PAC) has been shown to be effective in removing microcystin, a common cyanotoxin, from water. However, there is still a high level of uncertainty in determining proper PAC dosage and optimal removal conditions due to strong dependency on the water composition, PAC type, and presence of coagulants. In our study, experiments were conducted in batch and tested the role that different PAC type, pH, adsorbent dose, presence of coagulant (alum), and NOM play in the adsorption process. The equilibrium batch results show a correlation between PAC source material and removal efficiency. The wood based PAC shows the highest removal efficiency, which is consistent with the reported literature. The adsorption exhibits a dependence on pH as affinity of the toxin to PAC reflects changes in PAC surface charge. Competition by NOM reflects differences in the porosity of the PAC as opposed to differences in solution parameters. Additional tests evaluating the role of order of PAC and coagulant dosing and the interval between the dosing on treatment will be conducted. *Keywords: Powdered Activated Carbon, Microcystin-LR, Drinking Water Treatment.*

BAKER, T.R.[1], PITTS, D.K.[2], and ZHANG, Y.[3], [1]Institute of Environmental Health Sciences; Wayne State University, Detroit, MI, USA; [2]Department Pharmaceutical Sciences; Wayne State University, Detroit, MI, USA; [3]Civil and Environmental Engineering; Wayne State University, Detroit, MI, USA. **Wayne State University field station: the pilot plant at the GLWA's Water Works Park.**

The Great Lakes Water Authority (GLWA) Water Works Park is one of the largest drinking water plants in North America and supplies drinking water to approximately 40% of Michigan residents. The GLWA facility houses a Wayne State University field station for studying source water and treatment processes that includes a pilot plant and research laboratory. This field station also has modernized microscopy, multi-sample solid phase extraction and housing for aquatic test organisms. Faculty of WSU are involved in the assessment of contaminants of emerging concern at the water intake of the Detroit River (e.g., pharmaceuticals and endocrine disrupting chemicals), development of a biological approach for evaluating water quality that focuses on the detection of estrogenic and anti-androgenic activity in water samples, chemical analysis of the efficiency of the drinking water treatment processes and various methods of treatment optimization. The projects of the trans-disciplinary team will evaluate major urban water infrastructure and use a combination of vertebrate and invertebrate model organisms to create a molecular identification model that identifies chemical contaminants that may have adverse health effects. *Keywords: Detroit River, Field station, Drinking water, Monitoring.*

BALABAN, M.B.[1], CRAFTON, E.[2], CUTRIGHT, T.[2], and MOU, X.[1], [1]Kent State University, Kent, OH, USA; [2]University of Akron, Akron, OH, USA. **The Impact of Algaecides on Heterotrophic Bacterial Communities.**

When blooms of cyanobacteria in lakes used as water sources for municipal water treatment plants (WTPs) reach problematic levels due to high turbidity and/or toxins, some WTPs choose to apply algaecides to improve water quality. When using algaecides, WTPs want to use the minimum effective dose to limit unwanted side effects. The goal of this study was to see the potential effects of algaecides on the non-targeted bacterial community in lakes. Surface water samples were collected from three lakes used by WTPs, Lake Rockwell, Willard Reservoir, and Norwalk Reservoir. Collected water was incubated until it reached a high enough cyanobacterial cell count. Algaecide treatment was then run for samples of each water source by adding varying concentrations (100%, 50%, 25%) of three algaecidal chemicals, PAK-27, Cutrine Ultra, and EarthTec. Controls with no algaecide addition were included. After 14 days incubation, water was filtered through 3 μm and 0.2 μm polycarbonate filters to obtain particle-associated and free-living bacteria for DNA extraction. Water samples were taken at the beginning and end of the experiment and fixed using 10% paraformaldehyde before cell enumeration by florescence microscopy. T-RFLP analysis is performed to examine potential shifts in bacterial community structures due to algaecide treatments. *Keywords: Cyanophyta, Water distribution, Lake management.*

BARACCHINI, T.[1], WÜEST, A.J.[2], ODERMATT, D.[3], VERLAAN, M.[4], WUNDERLE, S.[6], LIEBERHERR, G.[6], and BOUFFARD, D.[1], [1]Physics of Aquatic Systems, École Polytechnique Fédérale de Lausanne (EPFL), Lausanne, SWITZERLAND; [2]Swiss Federal Institute of Aquatic Science and Technology (Eawag), Kastanienbaum, SWITZERLAND; [3]Odermatt & Brockmann GmbH, Zürich, SWITZERLAND; [4]Deltares, Delft, NETHERLANDS; [5]Mathematical Physics, TU Delft, Delft, NETHERLANDS; [6]Remote Sensing Research Group, University of Bern, Bern, SWITZERLAND. **Coupling In-situ and Remote Sensing Data with Three Dimensional Hydrodynamic Models.**

The importance of the spatial and temporal heterogeneity in the distribution of all trophic levels is now largely recognised. Understanding its dynamic is crucial to provide scientifically credible information for ecosystem management. Over the last decades, various research communities addressed this problem using different information sources, such as in-situ measurements, remote sensing observations and numerical simulations. The challenge of this study is to couple those information sources through adapted parameterization and data assimilation (DA) algorithms. We introduce here the first coupling of the 3D hydrodynamic modelling suite Delft3D-FLOW with OpenDA, an open-source generic platform for model calibration and DA. Using in-situ and remote sensing temperature

observations, preliminary results of an automatic parameterization and Ensemble Kalman Filtering are presented. Lake models parameterization is typically a tedious task, which this method aims at facilitating. In terms of DA, we present a flexible framework, tested on two Swiss lakes, capable of updating model results and parameters while accounting for the uncertainty of the system. Finally, the benefits of such framework are showcacased through the presentation of a new online hydrodynamic forecasting platform for Lake Geneva (http://meteolakes.epfl.ch). *Keywords: Lake model, Hydrodynamic model, Remote sensing.*

BARBIERO, R.P.[1], LESHT, B.M.[2], WARREN, G.J.[3], RUDSTAM, L.G.[4], WATKINS, J.M.[4], KARATAYEV, A.Y.[5], BURLAKOVA, L.E.[5], and REAVIE, E.D.[6], [1]CSRA, 1359 W Elmdale Ave, Chicago, IL, 60660, USA; [2]CSRA and University of Illinois at Chicago, 845 W. Taylor St., Chicago, IL, 60607, USA; [3]US EPA GLNPO, 77 W. Jackson Blvd, Chicago, IL, 60604, USA; [4]Cornell University, 900 Shackelton Point Rd, Bridgeport, NY, 13030, USA; [5]SUNY Buffalo State, 1300 Elmwood Ave, Buffalo, NY, 14222, USA; [6]University of Minnesota Duluth, 5013 Miller Trunk Hwy, Duluth, MN, 55811, USA. **A Comparative Survey of the Lower Food Web Across the Laurentian Great Lakes.**

The Great Lakes National Program Office (GLNPO) of the U.S. EPA has been conducting regular water quality monitoring surveys of the Laurentian Great Lakes since 1983. A unique aspect of this program is that since 1996, all five Great Lakes have been surveyed using consistent methodology, thus creating a basis for cross-lake comparisons. This data series has been supplemented since 1998 with chlorophyll estimates derived from remote sensing imagery. Since the initiation of the program, the lower food webs of the Great Lakes have undergone profound changes, including phosphorus declines in lakes Michigan, Huron and Ontario, oligotrophication in lakes Michigan and Huron, the convergence of zooplankton communities in lakes Michigan, Huron, and to a lesser extent Ontario, towards calanoid copepod dominance similar to that of Lake Superior, and declines in the benthic amphipod Diporeia in all lakes but Lake Superior. In spite of the similarity of trends in multiple variables across multiple lakes, the timing of these trends, and/or the timing of putative causative mechanisms, has not always been the same. Here we will examine the trajectory and timing of lower food web changes across the Great Lakes with the objective of shedding light on in which cases, and to what extent, such changes might be driven by similar causative factors. *Keywords: Nutrients, Zooplankton, Diporeia.*

BARKACH, J.[1], MILLER, C.J.[1], SELEGEAN, J.P.[2], and BABAKHANI, F.[1], [1]Wayne State University, 2158 Engineering Building, Detroit, MI, 48202, USA; [2]U.S. Army Corps of Engineers, 477 Michigan Avenue, Detroit, MI, 48226, USA. **Preliminary Analysis of Watershed Sediment Delivery to 30 USACE Great Lakes Harbors.**

Watershed sediment yield is the total amount of sediment generated within a watershed and delivered to the river outlet over a particular timeframe (e.g. one year). In a watershed, sediment yield includes erosion from the bed and banks of the river (gullies, bank failure, and mass wasting) minus the sediment deposited onto flood plains, and in the bed and banks of the river and other sediment sinks such as reservoirs, before it reaches the outlet. Excessive sedimentation at the watershed outlet to USACE navigation channels and harbors is an ongoing issue requiring periodic and expensive maintenance dredging to maintain the cut depths of the navigation channels. This presentation provides the preliminary estimates of watershed sediment delivery at 30 USACE harbors using a statistical model developed based on: watershed area; watershed slope; mean annual river flow, and 1.5 year and 2.0 year exceedance flows; land use; surficial geology; and, the trapping efficiency of dams located within the watershed. Similar empirical watershed models have been developed by others at much larger scales (Syvitski JPM, 2002; Syvitski JP and Milliman JD., 2007).The surficial geology, topography, and low gradient streams found in Michigan are typical of areas subject to multiple glacial advances that dominate the Great Lakes. *Keywords: Sediment transport, Sediment load.*

BARRETT, H.A., WIGDAHL-PERRY, C.R., and MASON, S.A., The State University of New York at Fredonia, 280 Central Ave., Fredonia, NY, 14063, USA. **The Effects of Plastic Pollution on Zooplankton.**

Concern over plastic pollution has been growing over the last ten years, particularly with respect to micro-plastics. Although the consumption of micro-plastics has been well documented, little is known on how their presence might affect the behavior of zooplankton. Zooplankton are microscopic organisms that feed on algae, common in lakes around the world, and are a major food source for fish. As filter feeders, they sift through the water column for algal cells where they could possibly be ingesting micro-plastics. As a main source of food for fish, this could be another vector for plastics to enter the food chain and reducing the amount of transferred energy through trophic levels. This presentation will discuss and on-going feeding study aimed at understanding the potential impact of micro-plastics on Great Lakes zooplankton communities. *Keywords: Microplastics, Zooplankton, Bioaccumulation.*

BARROWS, P.W.[1], NEUMANN, A.[2], BERGER, L.[3], and SHAW, D.[4], [1]Marine & Environmental Research Institute, Main Street, Blue Hill, ME, 04614, USA; [2]Adventure Scientists, PO Box 1834, Bozeman, MT, 59771, USA; [3]College of the Atlantic, Eden Street, Bar Harbor, ME, 04609, USA; [4]State University of New York, Albany, NY, USA. **Grab vs. neuston tow net: a microplastic sampling performance comparison.**

With the rapid evolution of microplastic research over several decades, there is an urgent need to compare methodologies for quantifying microplastic in aquatic environments. The most common method for surface sampling is a neuston net tow. Its effectiveness for microplastic research is limited by the net's mesh size as well as the likelihood of contamination. In our study, we compared a 1 L surface grab sampling method to a 335 mm neuston net tow. Grab sampling collected over three orders of magnitude more microplastic per volume of water as well as a smaller size range of plastic than sampling with a neuston net. For studies aiming to capture and sort larger microplastics without a microscope, the neuston tow method is preferred, since it samples a greater volume of water, increasing the potential of capturing microplastic pieces. Grab sampling can capture plastic at the micro- and nano-scale and in environments where neuston nets are impractical, but the small water volume sampled may result in high variability among samples. The comparison of these techniques comes at a critical time when sampling methods need standardization for the accurate measurement of the distribution and composition of microplastic in aquatic environments worldwide. *Keywords: Microplastics, Microfiber, Pollutants, Methodology.*

BASU, N.B. and VAN METER, K.J., University of Waterloo, 200 University Ave. W., Waterloo, ON, N2L3G1, CANADA. **Nutrient legacies in anthropogenic catchments: implications for water quality.**

Human modification of the nitrogen (N) cycle has resulted in increased flows of reactive N, contributing to the persistence of large hypoxic zones in inland and coastal waters. While the need to manage these flows is recognized, best management practices to reduce stream N concentrations have had only limited success. Some have attributed this lack of success to accumulation of legacy N stores from decades of fertilizer application. Here we use a coupled data-synthesis and modeling framework to (a) quantify the accumulated legacies in agricultural watersheds, and (b) model catchment scale time lags using both statistical and deterministic approaches. We analyze long-term soil data from the Mississippi River Basin to reveal significant increases in total N (TN) content, accounting for 43% of net anthropogenic N inputs. The presence of such legacy stores is utilized in the development of a framework for quantifying catchment-scale time lag times based on both soil nutrient accumulations and groundwater travel time distributions. *Keywords: Nutrients, Water quality, Biogeochemistry.*

BATTAGLIA, M.J., BROOKS, C.N., BOURGEAU-CHAVEZ, L.L., ENDRES, S.L., and GRIMM, A., Michigan Tech Research Institute, 3600 Green Ct. Ste. 100, Ann Arbor, MI, 48105, USA. **Evaluation of available geospatial data for determining wetland connectivity in the Great Lakes.**

Great Lakes coastal wetlands are at risk due to ongoing development and increasing effects of global climate change, such as fluctuations in water level and hydroperiod. Geospatial datasets are invaluable for understanding and protecting these important wetland resources. This project evaluated the available datasets relevant to coastal wetlands in the Great Lakes region, and to use these datasets to determine wetland connectivity and zones of coastal influence, which could be of great use to local management officials in coastal communities. Digital elevation data at varying resolutions was tested and compared for their utility in developing these outputs. Additionally, verification of recently created Great Lakes coastal wetland maps was carried out to determine which wetlands are hydrologically connected to the Great Lakes. Analysis was conducted for the Les Cheneaux Islands in Lake Huron and Luna Pier on Lake Erie to evaluate a range of wetland types and conditions that may be found in coastal Michigan communities. The results of this work are being translated into educational materials that will be usable by local officials who may not have the capacity or resources to use GIS. *Keywords: Coastal wetlands, GIS, Spatial analysis.*

BECHLE, A.J.[1] and WU, C.H.[2], [1]UW Sea Grant, Madison, WI, USA; [2]UW Madison Civil and Environmental Eng, Madison, WI, USA. **The 2014 Lake Superior Meteotsunami.**

A large meteorological tsunami wave struck eastern Lake Superior on September 4, 2014, overtopping the Soo Locks and flooding homes in Sault Ste. Marie, ON. Analysis of surface meteorological and radar data indicate that a strong thunderstorm moved eastward over the lake at the time of the event and was the likely cause of the meteotsunami. Throughout the lake, water level fluctuations were observed to be of moderate height (~30 cm) with a period of one hour and corresponded to the passage of the storm. Within Whitefish Bay, where the reported flooding occurred, the water level fluctuations increase to over 1 meter with a period of 4 hours. To investigate the processes behind this event, meteorological conditions are reconstructed to force a hydrodynamic model of the lake. The simulations reveal that both open-water long waves and coastally-trapped edge waves were generated by the storm as it propagated across Lake Superior. Upon reaching Whitefish Bay, these waves excited a natural oscillation mode of the bay, amplifying the wave to its final destructive height. *Keywords: Lake Superior, Water level fluctuations, Waves.*

BELETSKY, D.[1], ANDERSON, E.J.[2], and BELETSKY, R.[1], [1]University of Michigan, Ann Arbor, USA; [2]NOAA GLERL, Ann Arbor, USA. **Hydrodynamics of Western Lake Erie.**

Prediction of harmful algal blooms in Lake Erie depends on the accuracy of hydrodynamic models that provide information on lake circulation and temperature. Until recently, long-term observations of circulation in the western basin were practically non-existent, but in summer 2015 GLERL deployed 4 ADCPs that revealed highly variable circulation patterns. To evaluate model skill and better understand the dynamics of Lake Erie's western basin, we compare FVCOM model results with current and temperature observations conducted in Lake Erie. *Keywords: Hydrodynamic model, Hydrodynamics, Lake Erie.*

BENCE, J.R.[1], MARINO, J.A.[2], PEACOR, S.D.[1], and TRUESDELL, S.B.[1], [1]Department of Fisheries and Wildlife, Michigan State University, 480 Wilson Road, East Lansing, MI, 48824, USA; [2]Department of Biology, Bradley University, 06 Olin Hall, 1501 W. Bradley Ave., Peoria, IL, 61625, USA. **Fitting Dynamic Models to Time-series of Data: Musings About Current Approaches and the Future.**

Considered in a general context, state space models specify rules for making a transition from the current state to a state at a future time based on the current state variable values. These transitions are typically probabilistic and thus the state variables evolve randomly over time. A wide array of specific approaches used in the Great Lakes have been explicitly cast as state space models, while others are implicitly state space models. These have included occupancy models, dynamic factor analysis, dynamic linear models, dynamic growth and condition models, dynamic models of sea lamprey marking, statistical catch-at-age assessments, and size- or stage- based dynamic population models. Inferences about these models have been made from both Bayesian and Frequentist paradigms and even within a single paradigm different technical approaches have been used. State space approaches can be computationally challenging because they are often effectively complex nonlinear random effect models. In some cases, ad hoc, rather than formal state space inference approaches have been applied because of computational limitations. Common practice, computational issues, software advances, and future directions for applying such models will be discussed. *Keywords: Modeling, Statistical inference, State space models, Time series models.*

BENDER, L.B.[1], GLASE, J.D.[2], MORASKA LAFRANCOIS, B.M.[2], GAFVERT, U.[3], and GOSTOMSKI, T.[3], [1]National Park Service, Midwest Region, Munising, MI, USA; [2]National Park Service, Midwest Region, Ashland, WI, USA; [3]National Park Service, Great Lakes Inventory and Monitoring Network, Ashland, WI, USA. **Find Your (Underwater) Park: Benthic Mapping in Great Lakes National Parks.**

The National Park Service (NPS) protects diverse underwater environments in Lakes Michigan and Superior. These habitats historically received less attention than terrestrial areas in the parks, and until recently little was known about their bathymetry and character. With support from the Great Lakes Restoration Initiative, the NPS is developing high resolution bathymetric maps using LiDAR and multibeam sonar. Here we explore these emerging datasets, highlight unique cultural and geological features discovered along the way, discuss applications for management and research, and give details about data availability and access for broader use around the Great Lakes. These large and detailed maps will provide great opportunities for partnership between management agencies, academia, and the public. *Keywords: Great Lakes Restoration Initiative (GLRI), Sonar, Lake Superior, Lidar, Lake Michigan, Mapping.*

BENOY, G.[1], ARMSTRONG, N.[2], JENKINSON, W.[1], ROBERTSON, D.[3], and SAAD, D.[3], [1]International Joint Commission, Ottawa, ON, CANADA; [2]Manitoba Sustainable Development, Winnipeg, MB, CANADA; [3]United States Geological Survey, Middleton, WI, USA. **Implications of output from Red-Assiniboine River Basin SPARROW nutrient models for Lake Winnipeg.**

Excessive phosphorus (TP) and nitrogen (TN) inputs from the transboundary Red-Assiniboine River Basin (RARB) are linked to the proliferation of algal blooms in Lake Winnipeg. To facilitate a common understanding of nutrient loads and sources by jurisdiction and watershed across the basin, binational TP and TN SPAtially-Referenced Regressions on Watershed attributes (SPARROW) models were developed. Overall findings indicated that across the basin, agricultural inputs, followed by stream channels and point sources, were the greatest sources of nutrients and that >90% of them came from the Red River portion of the basin. By jurisdiction, ~60% of the nutrients came from the United States and ~40% came from Canada. Towards the restoration of Lake Winnipeg, the Province of Manitoba has notionally identified TP and TN concentration goals of 0.05 mg/L and 0.75 mg/L, respectively. This translates into an approximately 40% decrease in TP and TN loads from the Red River. SPARROW model output will be used to describe potential policy options for the reduction of TP and TN from the RARB. *Keywords: Lake Winnipeg, Water quality, Modeling.*

BERG, E.A. and PINTOR, L.M., The Ohio State University, 210 Kottman Hall, 2021 Coffey Road, Columbus, OH, 43201, USA. **Trade-offs Between Ecosystem Restoration and Biodiversity Maintenance in Lake Erie Coastal Wetlands.**

Historically, coastal wetlands provided important ecosystem functions to Lake Erie and the surrounding watersheds including nutrient retention and biodiversity support. Roughly 5% of Lake Erie coastal wetlands remain and most are diked, severing hydrological connections to Lake Erie and surrounding watersheds and impairing ecosystem functions. Efforts to restore hydrologic connectivity by removing dikes on the Western Lake Erie Basin (WLEB) within Ottawa National Wildlife Refuge (ONWR). Although restoring wetland hydrology is expected to have long-term benefits, short-term trade-offs may result from dike removal. For example, influxes of nutrients and sediments been shown to decrease the diversity of invertebrates, which support ecologically and economically important recreational fish and wildlife. We compared biodiversity of invertebrates in diked and undiked wetlands to explore trade-offs between ecosystem function and biodiversity conservation within a watershed context. Preliminary data on total phosphorus and total nitrogen concentrations indicate nutrient levels are lower in diked rather than undiked wetlands. Furthermore, undiked wetlands were not significantly different than those within Crane Creek, suggesting that restored wetlands may not be retaining nutrients and thus, failing to support this ecosystem service. *Keywords: Coastal wetlands, Nutrients, Bioindicators.*

BERTANI, P., LEE, S., YANG, H., LEE, J., and LU, W., The Ohio State University, Columbus, OH, USA. **Immuno-FET AlGaN/GaN Biosensors for Microcystin Detection.**

Conventionally, methodologies such as ELISA, PCR, and MC-LS are used to evaluate microcystin and other toxin concentrations in a given water sample. However, while very effective in many cases, these methods can be costly, time consuming, and possess a limited dynamic range. We present a semiconductor-based "Lab on a Chip" approach to attempt to enhance and simplify mycrocystin sample testing. Each testing chip, fabricated on an AlGaN/GaN (Aluminum Galium Nitride/Galium Nitride), has the ability to detect the presence of Microcystin-LR and other variants depending on how the device is functionalized. In this work, we focus on MC-LR as among all microcystins, MC-LR is generally considered to be the most toxic and important to sense. Each chip is approximately 2 cm x 2 cm and operates by exploiting the intrinsic charge attached to each Microcystin. This charge, utilizing the field affect, deflects or attracts charge flowing through the sensor and results in a change in electrical current (often denoted as ΔIds). This ΔIds varies depending on the concentration of microcystin in the water sample and allows for the quantification of the toxin. In laboratory conditions, ΔIds has been shown to give a 60-90% increase in current levels. *Keywords: Biomonitoring, Sample Analysis, Harmful algal blooms, Toxic substances.*

BHATTACHARYYA, D. and CITRIGLIA, M., Northeast Ohio Regional Sewer District, 4747 East 49th Street, Cuyahoga Heights, OH, 44125, USA. **Binding affinity of microcystin congeners to a commercial ADDA specific polyclonal antibody.**

The cyanobacteria produce secondary metabolites known as cyanotoxins that are toxic, of which microcystins (MCs) are most frequently associated with the algal blooms. The frequently used detection methods for MCs are ELISA, LC-MS/MS and qPCR. The varied cross-reactivity of the ELISA antibody with the congeners can account for the discrepancy in detection values amongst the methods. We studied the binding affinity of the

14 MC congeners to the ADDA specific polyclonal antibody of an ELISA kit and derived the four parameters of the logistic curve fit, and Log-Logit fits for the individual congeners. We observed that the binding patterns exhibited by the individual congeners were significantly different from the MC-LR. The EC50 and cross-reactivity of the congeners were compared to previously published values and were observed to be mostly similar. The EC50 values indicate that MC-RR (EC50=0.629ppb) has the least affinity, whereas [D-Asp3]MC-LR (EC50=0.275ppb) has the highest affinity for the ADDA specific antibody. We speculate that using a single correction factor for the cross-reactivity is erroneous. We used the four-parametric and log-logit equations to calculate the MC-LR equivalents of the congeners given the true concentration or vice versa. *Keywords: Environmental contaminants, Microcystis, Harmful algal blooms.*

BIALKOWSKI, W., Georgian Bay Great Lakes Foundation, 80 Burns Blvd, 419, King City, ON, L7B 0B3, CANADA. **Great lakes Routing Model with St Clair River Variable Conveyance.**

Great Lakes routing models use net basin supply data, hydraulic discharge equations for the St Clair River plus other connecting channels, and calculate the water levels for each lake, hence completing the water balance each month. The discharge equations assume a fixed conveyance capacity and are valid for some 30 years. The 2004 Baird Report by Dr. Rob Nairn uncovered previously undetected erosion of the St Clair River, hence illustrating that river conveyance can change between dredging projects, and invalidate existing discharge equations. A stochastic technique based on Kalman Filtering has been used to construct a variable conveyance function for the St Clair River from 1900 to 2017. When applied to the 2011 discharge equation developed by David Fay, of Environment Canada, the resulting routing model accurately predicts US Army Corps water level and flow data from 1900 to 2017. The original differential equations ran on a half day step size, have now been converted to difference equations to predict monthly means and now run on a Microsoft Excel spreadsheet. This model has been used to assess options for Lake Michigan-Huron level restoration. *Keywords: St. Clair River, Routing model, Great Lakes basin, Variable conveyance capacity, Modeling, Kalman Filter.*

BILLMIRE, M.G., BROOKS, C.N., BOSSE, K.R., SAYERS, M.J., SHUCHMAN, R.A., GRIMM, A., and SAWTELL, R.W., Michigan Tech Research Institute, Michigan Technological University, 3600 Green Ct., Ste. 100, Ann Arbor, MI, 48105, USA. **Enabling Increased Sharing of Great Lakes Remote Sensing Data.**

Remote sensing products of the Great Lakes provide opportunities for more synoptic coverage of important attributes of lentic waters. The Michigan Tech Research

Institute has developed the "Satellite Derived Great Lakes Remote Sensing" web portal to make it easier for interested scientists, citizens, agencies, and others to access these products through user-friendly geospatial visualization. Derived products include photic zone depth, Kd490, chlorophyll, suspended minerals, color dissolved organic matter, dissolved organic carbon, harmful algal bloom extent, lake surface temperature, and natural color imagery. Data have been extended temporally by analyzing archival MODIS imagery back to 2002. MTRI has been working closely with the Great Lakes Observing System, the NOAA Great Lakes Environmental Research Lab, and others to increase access to these and other remote sensing data. Web mapping services have been integrated with the new GLOS Data Portal as a demonstration of improved data sharing. *Keywords: Remote sensing, Data sharing, Geospatial visualization.*

BIRBECK, J.A. and WESTRICK, J.A., Wayne State University, 5101 Cass Ave,, Detroit, MI, 48202, USA. **Online Pre-concentration of Microcystins followed by LC-MS/MS.**

In 2015, US EPA announced an age-dependent drinking water Health Advisory for microcystin (MC) and cylindrospermopsin. The proposed MC monitoring protocol (US EPA Method 544) is complex and controversial as it requires MC sampling at both the source water intake and the entry points to the distribution system. In the traditional format, EPA method 544 was developed with offline solid phase extraction (SPE) to concentrate and clean up the sample to obtain the 0.021 µg/L MC minimal reportable limit (MRL). EPA method 544 requires one day for sample concentration using SPE, and a second day for analysis of the samples using LC-MS/MS. Our goal was to develop an online MC method to 1) decrease the workflow by limiting sample preparation and size, 2) minimize waste (SPE cartridges and solvents), 3) increase reproducibility, and 4) increase sensitivity to the low ppt range. Using a Thermo Scientific EQuan MAX Plus™ online sample concentrator system, we were able to reduce sample prep time from 8 hours per 8 samples to 1.5 minutes per sample, reduce sample size from 500 mL to 10 mL, use less surrogate (cheaper analysis), decrease sample analysis time from 26 minutes to 10 minutes, and achieve low ppt detection limits all while meeting the US EPAs MRL guidelines. *Keywords: Chemical analysis, Method development, Mass spectrometry, Microcystins, Harmful algal blooms.*

BOASE, J.C.[1], VACCARO, L.[2], ROSEMAN, E.[3], and READ, J.[2], [1]USFWS Alpena Fish and Wildlife Conservation Office, 7806 Gale Road, Waterford, MI, 48327, USA; [2]University of Michigan Water Center, 625 E. Liberty St., Suite 300, Ann Arbor, MI, 48104, USA; [3]USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105, USA. **Connecting science and practice to restore fish habitat in the St. Clair and Detroit rivers.**

Restoring aquatic habitats for fish populations and ecosystem services is a complex process that requires the integration of diverse expertise, new technologies and an adaptive management process. Despite decades of projects and many scientific advances, habitat restoration projects continue to generate unexpected outcomes that are often not fully documented or shared. In this opening talk, we will lay out some over-arching goals for the session: to identify and describe common principles, techniques, challenges, and research needs that can be used to improve fish habitat restoration outcomes. We will also reflect on our own 15 years of experience with fish spawning habitat projects in the St. Clair and Detroit rivers. After establishing and studying eight reef restoration projects, a number of lessons have emerged about both the bio-physical and social aspects of habitat restoration planning and implementation. Over time, the restoration team has documented an adaptive management process and identified strategies for each stage that have application to other restoration efforts that require multi-organization collaborations, adaptive planning, and targeted outreach. *Keywords: Fisheries, Great Lakes Restoration Initiative (GLRI), Habitats.*

BOCANIOV, S.A. and SCAVIA, D., Graham Sustainability Institute, University of Michigan, 625 E. Liberty, Suite 300, Ann Arbor, MI, 48104, USA. **Nutrient dynamics, transport and retention in Lake St. Clair: Insights from three-dimensional model.**

Lakes modify and attenuate nutrient fluxes but with different efficiencies due to relative importance of key mechanisms involved in nutrient dynamics. Such efficiencies and mechanisms are difficult to estimate with conventional field-observation based approaches. This creates uncertainties not only with the precise estimates of losses via nutrient transport through the lake but also with forecasting the lake responses to retain and export nutrients under the conditions when external loads are altered due to nutrient control measures in the watershed. Process-based modeling can provide a low-cost solution to improve our knowledge of nutrient dynamics in lakes. Here, we applied a coupled three-dimensional hydrodynamic and ecological model to Lake St. Clair to construct a numerical nutrient budget to understand the transport of nutrients, particularly phosphorus, through the lake. We calculated the loss rates and retention times for total phosphorus (TP) and dissolved reactive phosphorus (DRP) and demonstrate a seasonal pattern. The model results have also identified the key mechanisms involved in nutrient dynamics and demonstrated that the TP and DRP dynamics were not driven by the same mechanisms. *Keywords: Ecosystem modeling, Nutrients, Lake St. Clair, Nutrient retention, Modeling, Nutrient loads.*

BOCKWOLDT, K.A. and BOOTSMA, H.A., University of Wisconsin-Milwaukee, 600 E Greenfield Ave, Milwaukee, WI, 53204, USA. **Quantifying Phytoplankton Production in Post-dreissenid Lake Michigan.**

The food web of Lake Michigan has changed dramatically as a result of dreissenid mussel establishment. There is an apparent link between declining phytoplankton production and declines in commercial fishery yields, but post-dreissenid measurements of phytoplankton production are limited to a relatively small portion of the lake, and so the effects of mussels on the lake's trophic carrying capacity remains uncertain. During two whole-lake surveys in the spring and summer of 2016, measurements of phytoplankton production were made at two southern basin and three northern basin sites. In addition, continuous measurements of surface CO2 concentrations and variable chlorophyll fluorescence were made using an onboard flow-through system equipped with a fast-repetition-rate fluorometer. This study was the first to directly measure phytoplankton photosynthesis in the northern basin during both spring isothermal mixing and the summer stratified period. Results from both surveys suggest higher production in the northern basin, which contradicts expectations based on the biogeochemical differences between the basins. Possible causes of this spatial pattern include nutrient loading from Green Bay, greater internal phosphorus cycling due to greater depths in the north, and reduced grazing by dreissenid mussels in the northern basin. *Keywords: Phytoplankton, Photosynthesis, Lake Michigan.*

<u>BODAMER-SCARBRO, B.</u>[2], STAPANIAN, M.A.[1], and KOCOVSKY, P.M.[1], [1]US Geological Survey, 6100 Columbus Avenue, Sandusky, OH, 44870, USA; [2]CSS-Dynamac, 6100 Columbus Avenue, Sandusky, OH, 44870, USA. **Factors Driving Population Density of Mayfly Nymphs in Western Lake Erie 1999-2014.**

Hexagania spp. mayflies have fluctuated in abundance during the past century due to anthropogenic eutrophication, efforts to reduce it, and the establishment of Dreissena spp. mussels. We examine data from 1999-2014 to further examine hypoxia as a driver of nymph density. We assessed several regression models predicting density of first-year and second-year nymphs measured during April and May from several variables of hypoxia, predation potential, competition potential, densities of age-1 (for age 2) and age 2 (for age 1) using AICc and AIC weights. Density of age-1 nymphs was the only variable supported for age-2 nymphs. Density of age-2 nymphs, measures of hypoxia, and a measure of predation were supported for age 1 nymphs. Differences in production of age-1 nymphs from year T to year T+1 were inversely related to measures of hypoxia. High-magnitude decreases in density of age-1 nymphs were preceded by long periods of hypoxia, whereas high-magnitude increases in density of age-1 nymphs were preceded by short periods of the absence of hypoxia. The evidence suggests adult stock and predation influence Hexagenia density, but intermittent hypoxia can cause high-magnitude population declines. Future work should focus on stock-recruitment dynamics and late-instar mortality, which require data on emergence and adult density. *Keywords: Hypoxia, Mayflies, Modeling.*

BOEDECKER, A.R.[1], MARK, J.M.[1], CHAFFIN, J.D.[2], and NEWELL, S.E.[1], [1]Wright State University, 3640 Colonel Glenn Hwy, Dayton, OH, 45435, USA; [2]F.T. Stone Laboratory, The Ohio State University, 878 Bayview Ave., Put-In-Bay, OH, 43456, USA. **Sediments as a nitrogen source or sink to Lake Erie: the roles of denitrification and N fixation.**

For over two decades, Lake Erie has experienced cyanobacterial harmful algal blooms (HABs), of non-nitrogen-fixing genera (e.g., Microcystis), due to excess nutrient (nitrogen and phosphorus) inputs. Lake Erie's watershed is mostly agricultural, and fertilizers, manure, and drainage practices contribute to high nutrient loads. These practices supply the lake with bioavailable forms of nitrogen (N), and the lake sediments play an important role in the removal and/or recycling of these forms. Our investigation aims to clarify the role of Lake Erie sediments in ameliorating or exacerbating conditions that fuel HABs via the removal and/or recycling of excess N loading. Sediment cores were collected at four sites in the western basin of Lake Erie during summer 2016. Cores were incubated in a continuous-flow system with treatments of either no isotope addition (control), a ^{15}N -nitrate tracer, or a ^{15}N-ammonium tracer to help distinguish between nitrogen sinks (denitrification and anammox), nitrogen links (e.g., DNRA), and nitrogen sources (nitrogen fixation). We hypothesized that denitrification is the primary N removal mechanism, with net fluxes reversing to net nitrogen fixation later in the season as sediments become organic matter limited, a pattern observed in other temperate, eutrophic lakes.
Keywords: Biogeochemistry, Stable isotopes, Sediments.

BOEGEHOLD, A.G.[1], JOHNSON, N.S.[2], ALAME, K.[1], and KASHIAN, D.R.[1], [1]Wayne State University, Detroit, MI, 48216, USA; [2]United States Geological Survey, Hammond Bay, MI, USA. **Impacts of cyanobacteria on quagga mussel spawning and veliger mortality.**

Quagga mussels are highly fecund bivalves invasive to North American and Western European waters. Food availability may play a role in reproduction and development, whereas nutritious algae may stimulate dreissenid spawning and support veliger growth, while low quality food, such as bloom forming cyanobacteria, could be a hindrance. We investigated the role cyanobacteria play in regulating quagga mussel reproduction and veliger survival through a series of bioassays. Spawning was quantified through an assessment of gamete release in the presence of serotonin, a known spawning inducer, and several cyanobacteria strains. Veliger experiments were conducted as 6-day chronic toxicity studies with exposure to five concentrations of cyanobacteria to determine the LC50. For all assays, controls of artificial lake water were used. Spawning was suppressed by *Aphanizomenon flos-aquae*, while the LC50 for quagga mussels was well below 18 mg/L in all cases, which is considered bloom concentrations in the Great Lakes. Results from this study demonstrate an antagonistic relationship between cyanobacteria and quagga mussel reproduction and veliger survival. This information can be used to model mussel populations, and further research could reveal a possible control method to limit dreissenid reproduction. *Keywords: Cyanophyta, Reproduction, Dreissena.*

BOEGMAN, L.[1], DOROSTKAR, A.[1], and POLLARD, A.[2], [1]Dept. of Civil Engineering, Queen's University, Kingston, ON, CANADA; [2]Dept. of Mechanical and Materials Engineering, Queen's University, Kingston, ON, CANADA. **High-resolution simulation of internal hydraulic jumps and solitary waves in Cayuga Lake.**

The MITgcm was applied to simulate the multi-scale internal wave field in Cayuga Lake. The simulations had ~226 million computational cells, a horizontal grid resolution of 22x22 m and a vertical resolution of 0.5-2.95 m. The 22x22 m nonhydrostatic grid reproduced qualitatively the formation, propagation and shoaling of observed internal solitary waves (ISWs) using >10 grids along the wavelength and a lepticity of O(1). This ensured, respectively, that the waves were not aliased and physical dispersion predominated over numerical dispersion. Transverse shoaling of ISW packets on lateral boundaries was from topographic reflection and refraction, in agreement with published field observations from estuaries, which show ISW propagation in long narrow quasi-2D systems (e.g., Finger Lakes, lochs, fjords, estuaries and straits) is fundamentally 3D. A shock front was simulated to be an internal hydraulic jump, occurring at midbasin during strong winds. To our knowledge, this is the first simulation of an internal hydraulic jump (supported by field data) due to supercritical conditions in a lake. Topographically induced internal hydraulic jumps also formed when the front interacted with a topographic sill. These results help fill the gap in understanding and correctly modelling the multiscale 3D dynamics of internal waves in lakes. *Keywords: Hydrodynamic model, Internal waves, MITgcm.*

BOHLING, M.E.[1], BLICHARSKI, T.[2], BURNS, R.L.[2], EVANOFF, P.[3], LOVALL, S.[2], and O'MEARA, J.[4], [1]Michigan Sea Grant, Southgate, USA; [2]Friends of the Detroit River, Taylor, USA; [3]SmithGroup JJR, Ann Arbor, USA; [4]ECT, Ann Arbor, USA. **GLRI Leads to Successful Fish Spawning Reef Projects in the St. Clair & Detroit River AOCs.**

The development of a funding mechanism through the Great Lakes Restoration Initiative has led to construction of over 10 acres of fish spawning habitat in the St. Clair and Detroit River Areas of Concern. Historically, the St. Clair and Detroit rivers supported a diverse and productive fishery. Lake sturgeon, walleye and lake whitefish traveled to these rivers to spawn, depositing and fertilizing their eggs in rocky areas with fast-flowing currents. However, beginning in 1874, both the St. Clair River and Detroit River were extensively modified. The river bottoms were dredged to create deep channels for large, commercial

ships. The dredging and disposal of dredged materials such as dirt, sediment and rocks, changed the flow of the river and damaged the natural limestone reefs where millions of fish spawned (reproduced). These and other impacts -- including overfishing and shoreline development -- have dramatically reduced the populations of native fish, particularly lake sturgeon. Many natural resource professionals believe that the recovery of native fish is limited by a lack of adequate spawning habitat. Reef construction had been slow due to the lack of funding prior to the GLRI. The reef projects will help lead to the removal of 2 Beneficial Use Impairments in both AOCs. *Keywords: Habitats, Restoraion, Detroit River, Fish.*

BONSALL, A.J.R.[1], HOYLE, J.A.[2], and TUFTS, B.L.[1], [1]Queen's University, 99 University Avenue, Kingston, ON, K7L 3N6, CANADA; [2]Glenora Fisheries Station - Ontario Ministry of Natural Resources, 41 Hatchery Lane, R.R. #4, Picton, ON, K0K 2T0, CANADA. **Movement of Lake Whitefish (*Coregonus clupeaformis*) in the Bay of Quinte (Lake Ontario).**

The Lake Whitefish (*Coregonus clupeaformis*) is a cold-water fish species with ecological and commercial importance across the Great Lakes. In Lake Ontario, populations of Lake Whitefish have become depleted as a result of anthropogenic impacts and invasive species. The purpose of this project was to: 1) improve our understanding of seasonal movement patterns for Lake Whitefish within the Bay of Quinte, 2) assess Lake Whitefish behaviour during the spawning season, and 3) identify current spawning habitat. We used acoustic telemetry techniques to record the movement patterns of 10 Lake Whitefish during the 2016/2017 season. The tagged whitefish spent the spring/summer in the lower sections of the bay, with some migrating out into the main lake. Most of the tagged whitefish exhibited migratory behaviour during the fall spawning season, with movement towards four different spawning areas. After the spawning season, these fish migrated back into the lower sections of the bay to overwinter. Advancing our knowledge of Lake Whitefish movement within Lake Ontario will provide important insights into the natural history of these populations, which should be useful for future rehabilitation in this region. *Keywords: Bay of Quinte, Lake Whitefish, Movement Patterns.*

BOOTE, M.[2], MONDORA, K.[1], SIEDLACZEK, B.[1], BAILEY, A.[2], MULLETT, N.[3], ISZLER, E.[3], and O'MEARA, J.[1], [1]Alliance of Rouge Communties, 46036 Michigan Ave, Suite 126, Canton, MI, 48188, USA; [2]Environmental Consulting & Technology, Inc., 2200 Commonwealth Blvd., Suite 300, Ann Arbor, MI, 48105, USA; [3]Wayne County, 3600 Commerce Court, Building E, Wayne, MI, 48184, USA. **Improving the Rouge River AOC - Fish and Wildlife Habitat Improvement through GLRI Funding.**

The Alliance of Rouge Communities (ARC) has made significant progress toward eliminating the Benthos and Fish and Wildlife Habitat Beneficial Use Impairments (BUIs) for the Rouge River AOC under GLRI. Four projects have been the focal point of this work to date: Danvers Pond Dam Removal; Wayne Road Dam Removal; Henry Ford Estate Dam Fishway; and Oxbow Phase 3. Theses project had been identified as priority projects within the watershed to address the habitat and population BUIs within the AOC. The projects reconnect approximately 80 miles of the River and 230 miles of tributaries to the Great Lakes system, create 1,000 feet of new natural channel, remove over 7,000 cubic yards of debris, and create habitat structures. Accomplishing these restoration targets addresses three of the AOC BUIs: Loss of Fish and Wildlife Habitat, Degradation of Fish and Wildlife Populations, and Degradation of Benthos. The projects feature inter-related and mutually-supporting components: removal of the dams/channel barriers or creation of fishways to provide for passage, and related ecosystem improvements to restore habitat for fish and terrestrial wildlife. The removal of the barriers and the enhancements allows unencumbered fish passage, creates a natural buffer, and improves habitat and water quality in the system.
Keywords: Fisheries, Rouge River, Ecosystems, Great Lakes basin.

BOSSE, K.R.[1], SHUCHMAN, R.A.[1], SAYERS, M.J.[1], SCHWAB, D.J.[1], and LESHKEVICH, G.[2], [1]Michigan Tech Research Institute, 3600 Green Ct., Suite 100, Ann Arbor, MI, 48105, USA; [2]NOAA-GLERL, 4840 S. State Road, Ann Arbor, MI, 48108, USA. **Developing A Daily Composite Product for Water Quality Parameters in the Great Lakes.**

The Color Producing Agent Algorithm (CPA-A) is a bio-optical model used to estimate water quality parameters in the Great Lakes from satellite reflectance data. The algorithm's output products include chlorophyll, suspended minerals, CDOM, dissolved organic carbon, Kd, photic zone, bulk absorption, and bulk scattering. These products have been used to track spatial and temporal variability in the lakes, which has been corroborated by in situ data. Since 2013, MTRI has been sharing maps of these products derived from MODIS data for each Great Lake on multiple online data portals. Cloud cover limits the viable images to approximately one per week during the growing season (April-October), though occasionally several weeks go by without a good look at a lake. Using a particle tracking algorithm and the water circulation models developed by NOAA-GLERL, MTRI has developed a data assimilation technique that incorporates all satellite images within a given time period to generate a near-complete daily composite of the above-mentioned water quality products for the Great Lakes. These products will be shared on the online portals allowing stakeholders to visualize current conditions and study past behavior.
Keywords: Remote sensing, Water quality, Algae.

BOSTON, C.M.[1], RANDALL, R.G.[1], PORTISS, R.[2], HATRY, C.[3], and MIDWOOD, J.D.[1], [1]Fisheries and Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7S 1A1, CANADA; [2]Toronto Region Conservation Authority, 5 Shoreham Drive, Downsview, ON, M3N 1S4, CANADA; [3]Kilgour & Associates Ltd., 2285C St. Laurent Blvd., Unit #16, Ottawa, ON, K1G 4Z6, CANADA. **A description of the fish assemblages at habitat alteration sites in Toronto Harbour.**

The nearshore fish community in Toronto Harbour has been monitored extensively since 1989 to collect data on species composition, abundance and distribution, as well as to track changes in the fish assemblages over time. Sites with the largest data sets are known as RAP (Remedial Action Plan) sites and have been sampled routinely (1989-2016) since Toronto was designated as an Area of Concern while other data sets were focused around habitat alteration projects. We examined the temporal and spatial trends in nearshore fish assemblages using an Index of Biotic Integrity (IBI) designed for Great Lakes fishes with a focus on locations where fish habitat alterations have occurred and where both pre- and post- habitat alteration/construction data exist. The results of these analyses will help facilitate the understanding of the effects of habitat alteration on nearshore fish communities and inform future management decisions regarding fish habitat alteration along the Toronto waterfront. *Keywords: Habitats, Fish populations, Lake Ontario.*

BOURGEAU-CHAVEZ, L.L.[1], HIGMAN, P.J.[2], ELGERSMA, K.J.[3], CURRIE, W.S.[4], CRONK, K.R.[5], and VANDER HAAR, M.A.[6], [1]Michigan Tech Research Institute, Ann Arbor, MI, USA; [2]Michigan Natural Features Inventory, P.O. Box 13036, Lansing, MI, USA; [3]University of Iowa, Iowa City, MI, USA; [4]University of Michigan, Ann Arbor, MI, USA; [5]Saginaw Bay CISMA, Saginaw, MI, USA; [6]USFWS, Saginaw, MI, USA. **Implementing Adaptive Management and Monitoring for Restoration of Wetlands Invaded by Phragmites.**

Phragmites control efforts often lack explicit site-specific restoration goals, consideration of landscape context, multi-year planning and measurement of ecosystem level responses. In addition, root causes of invasion such as increased nitrogen loading are rarely considered or addressed. We will present the initial results of our project to integrate high resolution maps from remote sensing with modeling of nitrogen loading and hydrological connectivity to create an adaptive plan that targets specific treatment techniques and time intervals, based on specific site conditions in Saginaw Bay. We will also present a suite of monitoring protocols tied to a range of specific management objectives and quantify their costs. Appropriate monitoring is critically important for demonstrating that management is achieving its intended goals. Nitrogen loading, landscape and site level propagule pressure, age of stands, and treatment methods, sequence and frequency directly influence the success of *Phragmites* invasion. The availability of tools that enable and encourage managers to explicitly consider all of these factors will have huge implications for improving the management of invasive *Phragmites* in Saginaw Bay and elsewhere in the Great Lakes. *Keywords: Phragmites australis, Coastal wetlands, Monitoring.*

BOURGEAU-CHAVEZ, L.L.[1], ENDRES, S.L.[1], BROOKS, C.N.[1], SEROCKI, E.[1], CARLSON, J.[2], WANG, F.[2], BATTAGLIA, M.J.[1], and HIGMAN, P.J.[3], [1]Michigan Tech Research Institute, 3600 Green Ct, Ann Arbor, MI, 48105, USA; [2]Applied Ecological Services, 17921 Smith Road, Brodhead, WI, 53520, USA; [3]Michigan Natural Features Inventory, 530 W. Allegan St., Lansing, MI, 48933, USA. **Monitoring the Control of Invasive Phragmites australis to Inform Adaptive Management.**

An invasive phenotype of Phragmites australis has been aggressively colonizing coastal Great Lakes wetlands, negatively affecting habitat, biodiversity, and ecosystem health. Management (herbicide, burning and mowing) to control this aggressive invader has been implemented across the Great Lakes in many small and large efforts with varying degrees of success. Mapping the distribution of this invader and monitoring treatment areas for effects (e.g. standing dead stems, regrowth of the invader or restoration of native plants) are needed for effective management and control, however mapping and monitoring is often not included in control efforts. Recent research was conducted to investigate the effects of Phragmites treatment and to test the applicability of various mapping and field monitoring methodologies through comparison of paired treated and untreated Phragmites-dominant sites in Green and Saginaw Bays. High resolution (5 cm to 5 m) imagery was evaluated for: (1) its utility in development of comprehensive distribution maps that clearly show outliers, regrowth, standing dead and pathways of invasion at a fine enough scale to direct management actions; and (2) its use as a monitoring tool in comparison to field-based transect sampling. *Keywords: Remote sensing, Invasive species, Monitoring.*

BOZIMOWSKI, A.A., KOSIARA, J.M., and UZARSKI, D.G., Central Michigan University, Mount Pleasant, MI, 48859, USA. **The Use of a Passenger Ferry to Monitor Biota and Water Quality in Northern Lake Michigan.**

Long-term monitoring is important for early detection of exotic species, episodic events and the effects of climate change, while establishing predictive models. There are various monitoring initiatives in place throughout the Great Lakes basin, however long-term monitoring data was lacking for northern Lake Michigan. In 2016, the Central Michigan University Biological Station, Institute for Great Lakes Research and Beaver Island Boat Company formed a partnership to fill this gap. The Emerald Isle ferry transects northern Lake Michigan 51.5 km from Charlevoix to St. James, MI on Beaver Island up to four times daily from May to December. The ferry was outfitted with an onboard auto-sampling system to collect raw water for nutrient and plankton analyses. The system also includes a multiparameter sonde capable of collecting *in situ* readings of temperature, specific conductance, pH, DO, redox, chlorophyll, DOM, and turbidity every 2 minutes. A GPS unit and Smart-board relay panel which allows remote operation of the system are also onboard and live data is available to the public. Upon completion of our first sampling year, we present initial trends in nutrient and *in situ* water quality data. *Keywords: Water quality, Lake Michigan, Monitoring.*

BRADIE, J.N.[1], GIANOLI, C.[2], HE, J.[3], LO CURTO, A.[4], STEHOWER, P.[5], VELDHUIS, M.[6], WELSCHMEYER, N.[7], YOUNAN, L.[8], ZAAKE, A.[9], and BAILEY, S.A.[1], [1]Fisheries and Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7S 1A1, CANADA; [2]SGS Italia Spa, Via Compodoro 25, Villafranca Padovana (PD), 35010, ITALY; [3]Satake Corporation, 2-30 Saijo Nishihonmachi, Higashi-Hiroshima-shi, Hiroshima-ken, 739-8602, JAPAN; [4]Aqua-tools, 26 Rue Charles Edouard Jenneret, Poissy, 78300, FRANCE; [5]SGS Institut Fresenius GmbH, Rödingsmarkt 16, Hamburg, 22087, GERMANY; [6]Marine Eco Analytics, Havenkade 1A, Den Oever, 1779 GS, NETHERLANDS; [7]Moss Landing Marine Laboratories, 8272 Moss Landing Rd., Moss Landing, CA, 95039, USA; [8]Turner Designs, Inc., 1995 N. 1st Street, San Jose, CA, 95112, USA; [9]bbe Moldaenke GmbH, Preetzer Chaussee 177, Schwentinental, 24222, GERMANY. **Ballast Water Compliance Monitoring: Can Analytic Tools Rapidly Detect the Effects of UV-Treatment?**

The International Maritime Organization enacted the Convention for the Control and Management of Ships' Ballast Water and Sediments to limit the transfer of organisms by ships. Regulation D-2 restricts organism concentrations at discharge and ships are expected to comply by using on-board treatment systems to disinfect the ballast water. Port state control officers will need simple, rapid methods to detect compliance of discharged ballast water. Many indicative tools have been developed based on biomass indicators, but it is important to examine if the variable measured is appropriate for measuring the response of organisms to the applied treatment. We evaluated many detailed and indicative analytic tools to determine whether they can rapidly detect the effects of a treatment system based on UV disinfection. All devices detected a large decrease in concentrations of viable organisms ≥50 µm and < 10 µm, but results were more variable for ≥ 10 to < 50 µm organisms. Results confirm that it will be necessary to choose tools for compliance monitoring capable of detecting the damage inflicted on living organisms for UV treatment systems. This will be more important when monitoring < 50 µm organisms, since organisms ≥ 50 µm are generally eliminated by filtration. *Keywords: Monitoring, Invasive species, Ballast.*

BRADLEY, D.L.[1], BLACK, J.[2], and DIXON, D.[2], [1]LimnoTech, Ann Arbor, MI, USA; [2]EPRI, Palo Alto, CA, USA. **EPRI's Great Lakes 316b Interest Group: A Regulatory Workgroup Success.**

In 2014, EPA released its final rule regulating cooling water intake structures operated for the purpose of providing cooling water to power plants, manufacturing, and industrial facilities. Prior to the rule release, the Electric Power Research Institute (EPRI) organized a working group of power generators, located on the Great Lakes to collaboratively address pending challenges of regulatory compliance. Since 2014, the eleven companies, U.S. and Canadian, continues to share regulatory interpretation, technical resources, compliance information, data sources and technology developments. This talk will discuss the initiation, organization, progress, and successes of the workgroup as we move into our third year of activities. *Keywords: Regulations, Collaborations.*

BRAMBURGER, A.J.[1], REAVIE, E.D.[1], ESTEPP, L.R.[1], SGRO, G.V.[2], SHAW-CHRAIBI, V.L.[3], and PILLSBURY, R.W.[4], [1]Natural Resources Research Institute, University of Minnesota Duluth, 1049 University Dr., Duluth, MN, 55812, USA; [2]John Carroll University, University Heights, USA; [3]Tarleton State University, Stephenville, USA; [4]University of Wisconsin Oshkosh, Oshkosh, USA. **Size matters: Intra-generic relative abundance change in Great Lakes planktonic diatoms.**

Recent paleolinmological studies have shown increased relative abundance of *Cyclotellla sensu lato* species, as well as decreasing mean cell sizes at the assemblage level. Further, mean cell sizes within species have decreased over the past ~115 years and in general, large-celled taxa have decreased in relative abundance while their small-celled counterparts have increased in relative abundance. This phenomenon is even more pronounced at the intra-generic level. In many of the genera containing multiple species living sympatrically within the Great Lakes, large-celled species have been largely replaced by small-celled congeneric taxa. In some cases, large-celled taxa have disappeared completely from the sedimentary record. Specifically, 40% of large celled taxa (>10,000μm^3) that were present in sediments dating from the turn of the 20th century had effectively vanished by 1965, and all taxa that made their first substantial appearance in more recent sediments are characterized as small celled taxa (<6000μm^3). These findings support the classically-accepted notion of elevated levels interspecific competition among congeneric taxa and suggest that density effects and cell size responses are important selective agent among otherwise ecologically similar congeneric species in the Great Lakes. *Keywords: Paleolimnology, GLNPO, Climate change, Cell size, Diatoms.*

BRANDEL, A.M. and HUNTLEY, J.F., University of Toledo, Health Science Campus, 3000 Arlington Avenue, HEB258, Toledo, OH, 43614, USA. **Isolation and Characterization of Lake Erie Bacteria that Degrade the Microcystin Toxin MC-LR.**

Microcystin-LR (MC-LR) is a hepatotoxin produced by cyanobacteria, including *Microcystis* sp. and *Planktothrix* sp. Given that MC-LR contains seven amino acids (or modified amino acids), we hypothesized that some naturally-occurring Lake Erie bacteria may use MC-LR as a carbon source. Further, MC-LR-degrading bacteria could be used as biofilters to safely and cost-effectively remove MC-LR from drinking water. To test these hypotheses, we collected Lake Erie water samples over the last three summers, continuously added MC-LR to each water sample for 4-6 weeks to select for MC-LR-degrading bacteria, and assessed MC-LR degradation over time. To date, we have isolated and genotyped over 60 MC-LR-degrading bacteria, confirmed that none are potential human pathogens, and have demonstrated that the vast majority produce robust biofilms, indicating that biofilter development may be feasible. Studies currently are underway to examine the ability of laboratory-scale biofilters to remove MC-LR from water, examine MC-LR breakdown products by mass spectrometry analysis, and more comprehensively identify MC-LR-degrading bacteria using metagenomic sequencing. Taken together, these studies may lead to the development of new MC-LR mitigation strategies for municipal water treatment facilities. *Keywords: Microbiological studies, Microcystin, Water quality, MC-LR.*

BRENDEN, T.O.[1], KRUEGER, C.C.[1], HARRIS, C.[1], HERBST, S.J.[2], and VANDERGOOT, C.S.[3], [1]Michigan State University, 375 Wilson Rd, East Lansing, MI, 48824, USA; [2]Michigan Department of University, 525 West Allegan St, Lansing, MI, 48909, USA; [3]United States Geological Survey, 6100 Columbus Ave, Sandusky, OH, 44870, USA. **Tributary Use and Large-Scale Movement of Grass Carp in Western Lake Erie.**

Over the past 20 years, grass carp (Ctenopharyngodon idella) have been detected at low densities in Lake Erie, but were deemed a low threat because most were assumed to be triploid individuals and consequently reproductively sterile. Recent evidence suggests that wild recruitment of grass carp in Lake Erie is occurring, which has elevated concerns about population expansion and spread. Grass carp life history and behavioral aspects in the Great Lakes are unknown and these knowledge gaps hinder design of effective control strategies. The objectives of this study were to determine tributary use, locations of potential fish aggregations, and the extent of inter-basin movements in Lake Erie and the potential for expansion into other Great Lakes areas. To date, 32 grass carp have been collected and tagged with acoustic transmitters. Movement and tributary use of tagged fish is being monitored with strategically placed, passive acoustic receivers in combination with mobile tracking methods through collaboration with the Great Lakes Acoustic Telemetry

Observation System (GLATOS). Based on location data collected in 2015 and 2016, tagged grass carp appeared to selectively use larger tributaries. Although some tagged grass carp moved fairly long distances, to date no movement out of Lake Erie has been detected.
Keywords: Invasive species, Fish behavior, Lake Erie.

BRIGGS, A.S.[1], BOWEN, A.K.[2], KEPPNER, S.[3], LEWIS, T.[3], HALTNER, R.[3], COCHRAN, J.[3], LOUGHNER, J.L.[1], THOMPSON, P.A.[1], and HENSLER, S.R.[4], [1]U.S. Fish and Wildlife Service Alpena FWCO - Waterford Substation, Waterford, MI, USA; [2]U.S. Fish and Wildlife Service Alpena FWCO, Alpena, MI, USA; [3]U.S. Fish and Wildlife Service Lower Great Lakes FWCO, Basom, NY, USA; [4]Cerulean Center, Cedar, MI, USA. **Update of an Early Detection and Monitoring Program for Non-native Fishes in Lake Erie.**

The Alpena and Lower Great Lakes Fish and Wildlife Conservation Offices of the U.S. Fish and Wildlife Service have been conducting fisheries surveys since 2013 as part of an early detection and monitoring program for non-native species in the Lake Erie basin (Detroit River, Maumee Bay, Sandusky Bay, and Buffalo/Upper Niagara River). The goal of this program is to detect non-native species while they are still rare enough that eradication may be possible. Thus far, the program has focused on evaluating the amount of effort required to achieve a 95% detection rate of all species present at each sampling region. Multiple traditional gears have been used, including boat electrofishing, paired fyke nets, bottom trawls, and minnow traps. Based on rarefaction, 96.4% of species have been detected in the Detroit River, 94.0% in Maumee Bay, 45.2% in Sandusky Bay, and 80.5% in the Buffalo/Upper Niagara River. Boat electrofishing has captured the highest number of unique species in the Detroit River (n=10), Sandusky Bay (n=6), and Buffalo/Upper Niagara River (n=16), whereas paired fyke nets captured the highest number in Maumee Bay (n=17). Future evaluations will seek to improve non-native species detection efficiency.
Keywords: Invasive species, Lake Erie, Monitoring.

BRILAND, R.A., MANUBOLU, M., HU, C., LEE, J., MARTIN, J., and LUDSIN, S.A., The Ohio State Univeristy, Columbus, OH, USA. **Cyanobacterial bloom impacts on higher consumers in western Lake Erie.**

While the causes of cyanobacterial blooms are well established, the consequences to higher consumers are less clear. Cyanobacteria can act as an ecosystem engineer by reducing light intensity and penetration depth in the water column that may reduce foraging by visual predators and provide refuge for prey organisms. Moreover, cyanobacteria may produce microcystins that can negatively affect organisms and also bioaccumulate in the food web. To examine the effect of cyanobacterial bloom on aquatic food webs, we sampled water, phytoplankton, zooplankton, and fish (epipelagic and benthic) at discrete locations in Lake

Erie's western basin during August and September in 2013-2014. We used satellite imagery to guide our sampling, thus allowing for sampling across a wide cyanobacteria gradient. Sites with blooms were characterized by high algal biomass that was dominated by *Microcystis*, as well as high microcystin concentrations. We found strong positive relationships between cyanobacteria intensity and consumer abundance, including both zooplankton and small (age-0) prey fishes (e.g., emerald shiners, gizzard shad). While consumption by prey fishes was unrelated to cyanobacteria concentration, we did find high levels of microcystin in them. We discuss the implication of these findings for fisheries ecology and management.
Keywords: Food chains, Microcystis, Plankton.

BROADWAY, K.[1], SMITH, J.[2], OLDS, C.[3], and JONAS, J.L.[4], [1]Central Michigan University, 1200 S. Franklin St., Mount Pleasant, MI, 48858, USA; [2]Little Traverse Bay Bands of Odawa Indians, 7500 Odawa Circle, Harbor Springs, MI, 49740, USA; [3]U.S. Fish & Wildlife Service, 480 W Fletcher St., Alpena, MI, 49707, USA; [4]Michigan Department of Natural Resources, 96 Grant St., Charlevoix, MI, 49720, USA. **Morphological Assessment of Cisco Populations in Lake Michigan and Connected Inland Waterways.**

Interest in restoration of Cisco *Coregonus artedi* populations has been increasing, particularly in northern Lake Michigan where evidence exists of rapidly expanding populations. Populations in Lake Michigan are presently assumed to be of a single form often referred to as an *albus*-like (bay form) *artedi* ecotype, despite previous accounts of greater morphological and functional diversity in Lake Michigan. Contemporary assessments of Lake Michigan Cisco have been focused on collections from Grand Traverse Bay where early evidence of the expansion was most prevalent. However, the lake wide representativeness of the Grand Traverse Bay stock remains unclear. Also of interest is the relation of populations in connected inland waterways to Lake Michigan. In the present study, Cisco were collected from seven Lake Michigan sites (n = 153) and four inland lakes (n = 125) to assess the degree of morphological variation within the basin. Body and head shape were assessed using geometric morphometric methods on digitized images and variations in phenotypic characteristics were determined by eight linear anatomical measures and gillraker counts of individual fish. This study represents a practical first step in assessing the current morphological diversity of Cisco located within the Lake Michigan basin.
Keywords: Fisheries, Cisco, Lake Michigan, Morphology, Fish management, Grand Traverse Bay.

BROKUS, S.A.[1], FISHMAN, F.[1], KRUEGER, B.P.[1], PAYNE, C.E.[1], PEASLEE, G.F.[2], PIKAART, M.J.[1], TURNER, B.[1], WADE, R.W.[1], and BEST, A.A.[1], [1]Hope College, Holland, MI, USA; [2]University of Notre Dame, South Bend, IN, USA. **Longitudinal Monitoring of Microbial Populations and Nutrient Loads in the Macatawa Watershed.**

Project Clarity, a $1.2M restoration project initiated in 2013, works to restore Lake Macatawa and the Macatawa Watershed. Our goal is to assess Project Clarity's impact on water quality, collecting information about the watershed's microbial populations over several years to aid in decisions about public access to recreational waters and mitigation strategies. Project Clarity implements best management practices for land use in an attempt to minimize the impacts of rain events large enough to produce heavy runoff. These impacts include high sediment and nutrient loading which can result in algal blooms, the imbalance of biogeochemical cycling, and increases in environmental microbial activity. High levels of *Escherichia coli* have plagued the watershed over the last decade, leading to beach closures and a generally negative public view of water quality. Weekly samples from 12 representative sites were analyzed for biological (e.g., 16S community DNA sequencing, fecal indicator bacteria counts, *E. coli* genome sequencing), chemical (e.g., DO/BOD, nutrients), and physical parameters (e.g., T, pH). Over 80 genome sequences of *E. coli* have been sequenced and compared to coupled 16S community data. These data provide a baseline of biological and physical characteristics for monitoring of remediation efforts. *Keywords: Watersheds, E. coli, Microbiological studies, Genomics, Water quality.*

BROOKER, M.R.[1], EVERT, M.H.[1], LONGNECKER, K.[2], KUJAWINSKI, E.B.[2], and MOUSER, P.J.[1], [1]Civil, Environmental, and Geodetic Engineering Department at The Ohio State University, Columbus, OH, USA; [2]Woods Hole Oceanographic Institution, Woods Hole, MA, USA. **Discerning organic phosphorus signatures in pollutant sources from Lake Erie tributaries.**

The severity of harmful algal blooms (HABs) in Lake Erie is dependent upon loading of bioavailable-phosphorus (P) from its tributaries. Both point and nonpoint sources drive the development of HABs. Previously, attribution of source contributions has been made through intensive monitoring of PO_4 measurements. However, other forms of P, including P bound to organic matter, also contribute to lake loads and may be useful for source identification. The objective of this research is to investigate organic-P source signatures and track pollutant sources within a drainage basin. First, we optimized methods to recover organic-P from aqueous samples. Next, we applied extraction and concentration techniques to samples from the Sandusky River and five pollutant sources in the watershed: municipal wastewater effluent, edge-of-field, and chicken manure, dairy manure, and hog manures. Ultrahigh resolution mass spectrometry identified molecules across a 200-1000Da weight range. Our analysis detected 100s of organic-P formula across sample types. The river, edge-of-field, and wastewater effluent samples had the most similar signature while manures differed considerably from each other and the river. Research currently under way will apply

statistical techniques for characterizing end-members and evaluating mixed signals.
Keywords: Lake Erie, Phosphorus, Dissolved organic matter.

BROOKS, C.N.[1], MARCARELLI, A.M.[2], GRIMM, A.[1], HUCKINS, C.J.[2], and DOBSON, R.J.[1], [1]Michigan Tech Research Institute, 3600 Green Court, Suite 100, Ann Arbor, MI, 48105, USA; [2]Michigan Technological University - Department of Biological Services, 740 Dow Building, Houghton, MI, 49931, USA. **Using advanced mapping tools to help monitor Eurasian watermilfoil for improved treatment options.**

The invasive aquatic plant Eurasian watermilfoil (EWM), Myriophyllum spicatum, has been noted as a particular problem in nearshore regions of the Great Lakes and inland waters in recent years. It is well known for forming dense beds that interfere with recreation, crowding out native plants, and hybridizing with native milfoil species. Two GLRI and one Michigan DNR project have led to increased understanding of the genetic, biophysical, and chemical factors that influence the understanding of EWM ecology and likelihood of treatment success. These projects have used remote sensing tools to map areas containing EWM so that the treatment efficacy can be rapidly measured. Unmanned aerial vehicle (UAV) platforms and satellite imagery have been used to create maps of EWM and other macrophytes for Great Lakes study areas. Collection of spectral signatures using handheld and UAV-mounted spectrometers enabled identification of optimal spectral bands for differentiation of EWM from other macrophytes, which were used to select narrowband filters for mapping with a six-camera multispectral system. Lessons learned on geolocating data, sources of spectral variation, and impacts of high plant diversity on mapping results will be applied to another year of EWM mapping that coincides with treatment efforts in the Les Cheneaux Islands in 2017. *Keywords: Invasive species, Eurasian watermilfoil, Remote sensing, Monitoring.*

BROTHERS, S.M. and SIBLEY, P.K., University of Guelph, Bovey Bldg., Gordon St., Guelph, ON, N1G 2W1, CANADA. **Long-Term Metabolic Shifts in Lake Superior: A Case of Cumulative Effects?**

Surface dissolved oxygen (DO) concentrations measured across Lake Superior transitioned from supersaturation in the 1990s (and possibly earlier) to an apparent net undersaturation in the 2000s. Allochthonous carbon can determine atmospheric fluxes of DO in smaller lakes, but in Lake Superior the respiration-to-primary production (R:P) ratio is believed to control fluxes. However, Lake Superior is highly oligotrophic, and generally considered to be the most stable of the Great Lakes with respect to trophic status. Nevertheless, Lake Superior's surface water temperatures have risen more rapidly than in the other Great Lakes, and pelagic chlorophyll a concentrations have declined slightly.

Furthermore, its nutrient concentrations and water levels have historically been influenced by long-term (decadal) and/or large-scale climatic effects. We discuss several factors which may be causing the long-term changes in net DO saturation in Lake Superior, including changes in seasonal productivity, temperature, plankton size distribution, stratification, long-term nutrient dynamics, and dissolved organic matter. In particular, we explore the possibility that regional, large-scale shifts in R:P ratios in the water column may be the result of a cumulative effect of multiple factors, rather than being the result of one driver alone. *Keywords: Metabolism, Atmosphere-lake interaction, Lake Superior.*

BROWN, M.E.[1], ROTH, J.A.[2], SMITH, B.P.[3], and BOSCARINO, B.T.[4], [1]Hobart and William Smith Colleges, 300 Pulteney St, Geneva, NY, 14456, USA; [2]Skidmore College, 815 N Broadway, Saratoga Springs, NY, 12833, USA; [3]Ithaca College, 953 Danby Rd, Ithaca, NY, 14850, USA; [4]Poughkeepsie Day School, 260 Boardman Road, Poughkeepsie, NY, 12603, USA. **The Light at the End of the Funnel: Using Light-based Traps for the Detection of Hemimysis anomala.**

Early detection of non-native species can be challenging due to low densities, multiple life stages, and unpredictable conditions. We explored if subaquatic traps that utilize the behavioral response of organisms to preferred light conditions could effectively capture *Hemimysis anomala*, an invertebrate that is expanding its range throughout Europe and North America. Light-based traps provide a reliable alternative to monitoring with plankton nets and traps, as this invertebrate seeks refuge in crevices that are inaccessible to most sampling gear. In the field (Seneca Lake, NY USA), light-based traps of two designs--bucket and funnel traps--were highly effective at capturing *Hemimysis*, with limited non-target catch. Trap collections were representative of the juvenile-dominated population surveyed by net tows. In the laboratory, funnel traps were more successful than bucket traps at capturing *Hemimysis*. Once introduced into the trap, approximately 80% of organisms were retained, with no systematic difference in the demography between organisms that remained and those that escaped. As the behavior and life cycle of many species are tied to light intensity, the traps we describe for *Hemimysis* may be applied to the early detection of other species for which light preferences are know. *Keywords: Invasive species, Hemimysis anomala, Early detection.*

BROWN, T.N.[1], PAUER, J.J.[1], HOLLENHORST, T.P.[1], ZHANG, X.[2], and MELENDEZ, W.[2], [1]USEPA, Duluth, MN, 55804, USA; [2]CSRA, Grosse Ile, MI, 48183, USA. **A Nested Nearshore Nutrient Model (N^3M) for Nearshore Condition Assessment and Management.**

Nearshore conditions drive phenomena like harmful algal blooms (HABs), and the nearshore and coastal margin are the parts of the Great Lakes most used by humans. To assess conditions, optimize monitoring, and evaluate management options, a model of nearshore nutrient transport and algal dynamics is being developed. The model targets a "regional" spatial scale, similar to the Great Lakes Aquatic Habitat Framework's sub-basins, which divide the nearshore into 30 regions. Model runs are 365 days, a whole season temporal scale, reporting at 3 hour intervals. N^3M uses existing hydrodynamic model output and simple transport kinetics. N^3M's nutrient transport component is largely complete, and is being tested with various hydrodynamic data sets. The first test case covers a 200 km^2 area between two major tributaries to Lake Michigan, the Grand and Muskegon. N^3M currently simulates phosphorous and chloride, selected for their distinct in-lake transport dynamics; nitrogen will be added. Initial results for 2003, 2010, and 2015 show encouraging correlations with field measurements. Initially implemented in MatLab, the model is currently implemented in Python and leverages multi-processor computation. The 4D in-browser visualizer Cesium is used to view model output, time varying satellite imagery, and field observations. *Keywords: Algae, Nutrients, Hydrodynamics.*

BUCKNER, K.A.[1] and VERHAMME, E.M.[2], [1]Council of Great Lakes Industries, 3600 Green Court, Suite 710, Ann Arbor, MI, 48105, USA; [2]LimnoTech, 501 Avis Dr, Ann Arbor, MI, 48108, USA. **Industry Perspective on Great Lakes Issues.**

Many of the issues plaguing the Great Lakes can affect the many industrial users across the region. The severity of the impacts can affect everything from the cost of basic goods and services to drinking water quality. Water levels affect shipping traffic in and out of ports, invasive species affect water intakes, and climate change affects severity of severe storms and runoff characteristics. This highlight is meant to highlight the research efforts and needs of the private sector across the Great Lakes and encourage cooperation with other researchers. Areas where cooperation has benefited researchers and operators include monitoring HABs in Lake Erie and tracking debris that could clog power plant intakes in Lake Michigan *Keywords: Industry, Policy making, Planning.*

BUERKENS, F.C., NELSON, W.H., and MILLS, C., Fluid Imaging Technologies, 200 Enterprise Dr, Scarborough, ME, 04074, USA. **Continuous Imaging Flow Cytometer for Detection and Monitoring of Cyanobacteria and Microalgae.**

Various technologies utilize fluorescence measurements to detect cyanobacteria and estimate biovolume or cell counts within a water system. While useful in trending applications, results from fluorometers can be significantly skewed by turbidity and the presence of other fluorescing pigments, and little if any taxonomic information can be obtained. Fluid Imaging Technologies has recently adapted their imaging flow cytometer, FlowCam, so that it can detect the presence of the phycocyanin pigment in cyanobacteria

and, through imaging and the instrument's image recognition software, provide for organism identification, biovolume calculation, growth rate monitoring, health of the population, and many other population specific dynamics. In addition to detecting the phycocyanin pigment, the instrument is also able to detect and characterize chlorophyll, allowing for one instrument to be used in the detection, monitoring and identification of all microalgae. Here we present an overview of the technology along with field data from natural samples.
Keywords: Cell counts, Microcystis, Microalgae, Cyanophyta, Flow cytometry, Monitoring.

BUFFINGTON, K.L.[1], BROWN, M.E.[1], RAZAVI, N.R.[2], and CLECKNER, L.B.[2], [1]Hobart and William Smith Colleges, 300 Pulteney St, Geneva, NY, 14456, USA; [2]Finger Lakes Insitute, 601 South Main Street, Geneva, NY, 14456, USA. **Mysids and MeHg biomagnification: the role of species, habitat, age and sex.**

Hemimysis anomala is native to the Ponto-Caspian and was introduced to the Laurentian Great Lakes through ballast water and subsequently spread to inland lakes. Non-native species can be an important tool for learning about the fate of contaminants, and, as omnivores with ontogenetic diet shifts, *Hemimysis* have the potential to change a system's capacity to bioaccumulte and biomagnify contaminants. We compared methylmercury (MeHg) concentrations and the foodweb position (via stable isotopes) of Hemimysis between (1) juvenile and adult life stage, (2) adult males and females, (3) individuals in Seneca Lake (NY, USA) and the Seneca-Cayuga Canal, and (4) *Hemimysis* and the native mysid (*Mysis diluviana*) in Seneca Lake. The MeHg concentrations varied based on several variables. *Hemimysis* collected in fall (115.11 + 55.96 ng/g dw) had a lower MeHg concentration than those collected in winter (300.43 + 79.07ng/g dw), which likely resulted from a greater proportion of adults with higher biomass-driven contaminant load in the over-wintering population. Additionally, mean MeHg concentration in *M. diluviana* (60.05 + 14.59ng/g dw) was lower than *Hemimysis*. We discuss our findings in light of potential differences in diets and contaminant depuration upon brood release.
Keywords: Biomagnification, Mercury, Biological invasions.

BURKETT, E.B. and WINKLER, R.L., Michigan Technological University, Houghton, MI, USA. **Exploring relationships between Great Lakes salmon stocking and recreational fishing participation.**

Despite nationwide declines in recreational fishing participation and recent decreases in Pacific salmon stocking, Great Lakes salmon fishing remains important. Using a demographic research method called Age-Period-Cohort (APC) analysis, we estimated the impacts of angler age, time period, and angler birth cohort on likelihood to fish. This allows for projecting future angler populations and understanding angler motivations, and in

particular what specific cohorts of people may drive demand for Pacific salmon. APC analysis of license data from Illinois, Indiana, Michigan, Minnesota, and Wisconsin for 2000-2014 shows variations in the demographic characteristics of salmon and trout anglers. Men and women between the ages of 30 and 40 are the most likely to fish the Great Lakes for salmon, but the birth cohorts most likely to fish for salmon/trout vary by lake. For example, individuals born between 1950-1970 are more likely to fish for Lake Michigan salmon. This poster estimates past and future Great Lakes salmon angler participation by lake fished and explores the connections between fishing conditions (e.g., fish stocking levels) when anglers came of age and their likelihood to fish over the course of their lifetime. It also considers the critical implications of angler cohort effects for salmon fisheries management.
Keywords: Salmon, Management, Fishing.

BURLAKOVA, L.E.[1], KOVALENKO, K.E.[2], SCHMUDE, K.L.[3], BARBIERO, R.P.[4], KARATAYEV, A.Y.[1], and LESHT, B.M.[4], [1]Great Lakes Center, Buffalo State College, 1300 Elmwood Ave., Buffalo, NY, 14222, USA; [2]Natural Resources Research Institute, University of Minnesota-Duluth, 5013 Miller Trunk Highway, Duluth, MN, 55811, USA; [3]Department of Natural Sciences, University of Wisconsin-Superior, 801 N. 28th St., Superior, WI, 54880-5400, USA; [4]CSRA, 1359 W. Elmdale Ave, Suite #2, Chicago, IL, 60660, USA; [5]Department of Earth & Environmental Science, University of Illinois at Chicago, 845 West Taylor Street, Chicago, IL, 60607-7059, USA. **Developing Water Quality Indices Based on Great Lakes Benthos: Traditional and Modeling Approaches.**

Pollution tolerance of oligochaetes has long been used for water quality monitoring, and an Oligochaete Tolerance Index (OTI) was adopted by the US EPA Great Lakes National Program Office and by the State of Great Lakes Conference to assess trophic status from benthic monitoring data. OTI, however, is based on a limited number of species belonging to a single oligochaete class, depends on expert opinions for species assignment to trophic groups, and has never been tested to evaluate its correlation with lake productivity. To address these problems, we developed two new indices based on the OTI formula by (1) expanding and reviewing previous classifications of oligochaete species to trophic groups (iOTI) and (2) adding non-oligochaete species (mTI). Finally, we tested a modeling approach using Modern Analogue Technique (MAT) transfer functions based on species responses to a chlorophyll gradient to derive assessment of site status and an independent assignment of species to trophic categories. We found that both iOTI and mTI had a stronger relationship with surface remote-sensed spring chlorophyll than the OTI did, but MAT models were superior to OTI-derived models. *Keywords: Benthos, Index, Water quality, Modeling.*

BURT, R. and LAVELLE, S., Chelsea Technologies Group, Surrey, ENGLAND. **FastBallast - Rapid On-board Compliance Testing for Ballast Water Discharges.**

Following ratification in 2016 the IMO Ballast Water Convention will finally enter into force in September 2017. The D2 regulations outline the biological standards that discharged ballast water is required to meet. This has driven the development of tools for on-board and shore based compliance testing. The most predominant on-board rapid test devices address the 10-50um algae D2 group. These are generally based on bulk chlorophyll fluorescence to measure the maximum photosynthetic efficiency and only provide an indication of compliance. Chelsea Technologies has been working with ballast water treatment system manufacturers, test laboratories and the US Coast Guard to develop a portable, rapid test device that will determine whether discharged ballast water is compliant with the D2 regulations. Using an array of LEDs, a rapid flash rate and a sensitive photomultiplier FastBallast uses the distributed fluorescence method to measure single turnover cycles to quantify the minimum photosynthetic efficiency. This enables a cell density estimate that considers cell size as well as the specific fluorescence emission. Due to the high sampling rate this can also be applied to moving water applications such as an integrated device for continual measurements within ballast water treatment systems.

Keywords: Ballast, Invasive species.

BURTON, J.[1], SEYMOUR, L.[2], CASTOR, J.[1], and VAARA, A.[1], [1]Hubbell Roth & Clark, 555 Hulet Drive, Bloomfield Hills, MI, 48303, USA; [2]Macomb County Office of Public Works, 21777 Dunham Road, Clinton Township, MI, 48036, USA. **Innovative Project Management Produces Results.**

The Clinton River PAC has been in existence for over 40 years in support of the AOC program. The history of collaboration enabled the communities and agencies to move quickly when the GLRI funding opportunity became available specifically related to the removal of habitat focused BUIs. This presentation will highlight project development from pre GLRI tasks, forming partnerships across communities, counties, and local and state agencies, prioritizing projects, securing funding, and using various project delivery methods to produce results for two grant recipients, MCPWO and the City of Sterling Heights. Specifically, the presentation will focus on: Pre GLRI identifying of needs, forming partnerships, , early determination of potential obstructions, and making investments in potential projects. AOC-PAC evaluation, prioritization, and selection of projects from a project sponsor perspective. Delivering funded projects in the specified EPA time frame using various project delivery methods such as conventional design-bid-build methods to a modified design-build style delivery, and hybrids of these. *Keywords: Environmental effects, Great Lakes Restoration Initiative (GLRI).*

BYAPPANAHALLI, M.N.[1], KELLY, K.P.[1], AUNINS, A.[2], ISHII, I.[3], SHIVELY, D.[4], SPOLJARIC, A.[4], and NEVERS, M.B.[1], [1]U.S. Geological Survey, Great Lakes Science Center, Lake Michigan Ecological Research Station, 1574 N 300 E Kemil Road, Chesterton, IN, 46304, USA; [2]Natural Systems Analysts, Inc, 11649 Leetown Road, Kearneysville, WV, 25430, USA; [3]University of Minnesota, 1479 Gortner Avenue, St. Paul, MN, 55108, USA; [4]Michigan State University, 1449 Engineering Research Ct, East Lansing, MI, 48824, USA. **Cladophora microbiome: Who is there and what are they doing?**

The green alga *Cladophora* is native to the Great Lakes, but has become an environmental stressor. Algal mats are a natural substrate for microorganisms, but little is known about microbial abundance, diversity, and function. The objective of this study was to characterize the *Cladophora* microbiome using whole genome sequencing. *Cladophora* (n =34) was collected from several locations around Lake Michigan and DNA was extracted using MoBio PowerBiofilm kit. Ten samples were sequenced using an Illumina NextSeq500, with read lengths of 150bp; both fragment ends were used to generate paired-end reads. Sequence reads representing archea, bacteria, and eukarya were found, with reads ranging from 26,101,374 (urban location) to 60,891,592 (National Park site); Proteobacteria were among the dominant bacterial phyla. Twenty-eight functional groups were identified by SEED annotation, including nutrient metabolism, biosynthetic pathways, and disease and virulence functions. Nitrogen-fixing genes (*nifH*) were common (4.31 to 6.57 log copy numbers/g fresh weight), indicating that biotic nitrogen fixation may augment algal nitrogen needs. *Cladophora* has a rich and complex microbiome, and given its abundance in the Great Lakes, it likely influences multiple biotic pathways and food web functions.
Keywords: Cladophora, Microbiome, Ecosystem health, EDNA, Microbiological studies.

BYUN, K., HAMLET, A.F., and CHIU, C.M., University of Notre Dame, Notre Dame, IN, 46556, USA. **Projected Changes of Hydrologic Extremes over the Midwest and Great Lakes Region.**

Despite an increasing body of evidence from observed data that climate variability combined with regional climate change has had a significant impact on hydrologic cycles in the Midwest and Great Lakes region, there remains a critical question on how hydrologic extremes such as floods and droughts will be altered with respect to their magnitude and seasonal patterns in the future. To better understand changing patterns of extreme high and low flows, we conducted hydrologic model experiments in 40 watersheds in the Midwest/Great Lakes region using the Variable Infiltration Capacity (VIC) at 1/16 degree resolution for both historical and several future periods. For future projections, the Hybrid Delta statistical downscaling approach applied to CMIP5 GCM scenarios was used to produce meteorological driving data for the VIC hydrologic model. Using simulated daily streamflow and traditional flood frequency analysis techniques, future projections show increasing and decreasing magnitude of the 100-yr flood in different watersheds, and relatively small negative changes in 7Q10. Watersheds that flood in the early spring tend to show increases in flood risk in the simulations, whereas watersheds with a reduced snowmelt peak in the late spring show decreasing flood risk as well as significant earlier shifts of peak timing. *Keywords: Hydrologic cycle, Hydrologic extreme, Climate change, Modeling.*

BZONEK, P.A.[1], KIM, J.[2], and MANDRAK, N.E.[1], [1]University of Toronto Scarborough, 1265 Military Trail, Toronto, ON, M1C 1A4, CANADA; [2]Fisheries and Oceans Canada, 867 Lakeshore Rd, Burlington, ON, L7S 1A1, CANADA. **Responses of Common Carp to Acoustic and Strobe-Light Behavioural Barriers in a Lab and Mesocosm.**

Asian carps represent an imminent threat to the Great Lakes ecosystem. Acoustic and strobe-light behavioural barriers have been identified as potential tools to limit the spread of Asian carps in the Great Lakes. Urgent research is needed to understand how these stimuli impact behaviour and to evaluate the potential barrier efficacy within realistic canal environments. This study investigated the behavioural consequences of exposing Common Carp (*C. carpio*) to local stimuli through video-recorded wet-lab trials (n=44). There were no behavioural differences between either acoustic, strobe-light or combined stimuli. Carp spent more time swimming actively during the stimulus and post-stimulus periods than they did during control periods (30 min period duration). During the post-stimulus period, the number of passes made across the stimulus also increased. Additionally, Common Carp (n=6) and Buffalo (*Ictiobus sp.*)(n=3) movement was analyzed in a large mesocosm where fishes exposed to the same stimuli were monitored through acoustic telemetry. Acoustic stimuli did not produce significant movement responses. Strobe lights (n=12) produced smaller utilization distributions, a decrease in relocations, and an increase in travel velocity near the stimuli (<30m). This research will help inform Asian carp management decisions. *Keywords: Invasive species, Fish behavior, Carp.*

C

CANNON, D.J. and TROY, C.D., Purdue University, West Lafayette, IN, USA. **Examining the Importance of Stratification and Unsteadiness in Law-of-the-Wall Velocity Scaling.**

We use a high-resolution set of ADCP measurements from the deep (55m) hypolimnetic waters of Lake Michigan to investigate the validity and limitations of using law-of-the-wall (LOW) scaling to approximate velocity structure within the bottom boundary layer (BBL), a topic of interest for researchers who hope to model physical and biological processes that rely on estimates of bottom-stress and roughness. In spite of the weak currents (U_{1m}=3cm/s), logarithmic velocity structure is found within the bottom 1m of flow over 90% of the time, with 1m drag coefficient and roughness values of 0.0044 and 0.0015m, respectively. Despite this, drag coefficients show strong speed dependence, with large standard errors at low speeds (U_{50}<2cm/s). Log-linear modifications to the LOW are used to explain this phenomenon, with the increased scatter in drag coefficients largely attributed to seiche-scale unsteadiness. While the effects of stratification are deemed unimportant to near-bed flow structure, its effects on flow outside the BBL are appreciable and well-resolved by log-linear LOW modifications. Finally, we discuss the combined effects of stratification and unsteadiness to provide guidance for the implementation of log-linear modifications in estimating drag coefficients and log-layer depths. *Keywords: Lake Michigan, Bottom sampling, Hydrodynamics.*

CARRICK, H.[1], RUDSTAM, L.[2], WARNER, D.[3], and VANDERPLOEG, H.A.[4], [1]Dept. of Biology 7 Institute for Great Lakes Research, Central Michigan University, Mt. Pleasant, MI, 48859, USA; [2]Dept. of Natural Resources, Cornell University, Ithaca, NY, USA; [3]Great Lakes Science Center, United States Geological Survey, Ann Arbor, MI, USA; [4]Great Lakes Environmental Research Laboratory, National Oceanic and Atmospheric Administration, Ann Arbor, 48108, USA. **Plankton dynamics in Lake Michigan along a near to offshore gradient in Lake Michigan.**

Lake Michigan has experienced recent changes in the phytoplankton assemblage coinciding with reductions in watershed nutrient loadings and the introduction of invasive species. As such, we evaluated the population dynamics of key plankton components in Lake Michigan along a series of near to offshore transects in southern Lake Michigan (2015). Chlorophyll analysis revealed that the picoplankton fraction (Ppico, <2 µm) contributed an average of >50% to total phytoplankton biomass throughout the lake. The abundance of Ppico (5,200 to 70,700 cells/mL) was considerable on all dates and the assemblage was dominated by several cyanobacteria taxa and few pico-eukaryotes. The occurrence of diatoms (mainly Cyclotella and Discotella taxa) was limited to the nearshore region during the spring and early stratification periods. We estimated growth and grazing losses attributable to small grazers (microzooplankton, protists) and large grazers (meso-zooplankton, crustaceans) from enclosure experiments. Ppico experienced lower growth (0.19 +/- 0.27) relative to grazing losses by microzooplankton (-0.33 +/- 0.37), indicating tight coupling with small grazers. Given that Ppico are now more abundant than larger phytoplankton, these results suggest that carbon flow from Ppico to metazoa may dominate the current, trophic dynamics in the lake. *Keywords: Lake Michigan, Spatial variation, Phytoplankton.*

CASTAÑEDA, R.A., SOTÓ-VARGAS, J.S., MOLNÁR, P.K., and MANDRAK, N.E., University of Toronto Scarborough, 1265 Military Trail, Toronto, ON, M1C1A4, CANADA. **Estimating fish densities using underwater cameras.**

The use of underwater cameras to detect and monitor fishes is becoming increasingly popular in freshwater systems, especially for species at risk, due to its passive and non-invasive characteristics. However, standardized methods in quantifying fish populations is difficult due to the lack of spatial reference of camera images, the inability to recognize specific individuals, and the 3-D and turbid nature of water. Therefore, novel approaches are required to calculate fish densities that take into account these confounding factors. In this study, we developed a mathematical model to calculate fish densities using underwater cameras. This method does not require identification of individuals and allows for the estimation of densities. The model was tested in manipulated tank experiments in which GoPro camera trials were run over a turbidity gradient where known species densities were held constant. To estimate how encounter rates may be affected by altered fish behaviour due to the camera presence, these trials were run with clear and blackout cases. To understand how observer identification bias and turbidity may affect encounter rates, the trials were also run with red and magenta filters for image correction. The results of this research elucidate the strengths and limitations of using underwater cameras to enumerate fishes. *Keywords: Fish populations, Underwater cameras, Mathematical models, Fish behavior.*

CASTLE, D.K.[1], KOLB, T.[2], GALAROWICZ, T.L.[1], and ROSEMAN, E.F.[3], [1]Central Michigan University, Mt. Pleasant, MI, USA; [2]MI Department of Natural Resources, Lansing, MI, USA; [3]USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105, USA. **What'dya Catch?: An introduction to a research project analyzing creel survey data in the SCDRS.**

The St. Clair-Detroit River System (SCDRS) is one of the most targeted areas to fish by anglers from all over the world. The SCDRS has an open season all year for most species, providing diverse opportunities to anglers throughout the system. The Michigan Department of Natural Resources and the Ontario Ministry of Natural Resources conducted creel surveys during the early 2000s to 2015 to assess angler preferences and catch. During 2002-2005, aerial counts and roving creel surveys were conducted to sample both anglers and their catches throughout the St. Clair-Detroit River System. In 2012 and in 2015, a single roving survey was conducted in the St. Clair River and then in the Detroit River, respectively. Angler counts and effort (hours) were determined in order to quantify use of the system. In some cases, biological data was collected from angler catches, such as fish length, weight, species caught, bait used, etc. This presentation will introduce a research project that will analyze these creel survey data. *Keywords: Bioenergetics, Diets, Walleye.*

CAVE, K.[1], RIDGWAY, J.[2], SIEDLACZEK, B.[2], MULLETT, N.[1], and O'MEARA, J.[3], [1]Wayne County Department of Public Services, 400 Monroe, Suite 400, Detroit, MI, 48226, USA; [2]Alliance of Rouge Communties, 46036 Michigan Ave, Suite 126, Canton, MI, 48188, USA; [3]Environmental Consulting & Technology, Inc., 2200 Commonwealth Blvd., Suite 300, Ann Arbor, MI, 48188, USA. **The Rouge River AOC - A Multi-Year, Multi-Level Successful Approach to AOC Restoration.**

The Rouge River National Wet Weather Demonstration Project is a working example of how a holistic approach (considering impacts from all sources of pollution and use impairments) to pollution management can result in cost-effective and ultimately greater and faster achievement of water quality restoration. The Rouge Project was initiated in 1992 by Wayne County, Michigan. This cooperative effort between federal, state and local agencies has been supported through multi-year federal grants from EPA with additional funding from NOAA, local communities and other stakeholders. The early focus of the Rouge Project was on the control of combined sewer overflows. The work quickly expanded to address other impairments such as sanitary sewer overflows, storm water runoff, and discharges from illicit connections and failed onsite septic systems. Streambank stabilization, riparian corridor management, and green infrastructure and habitat restoration projects were also completed to address AOC concerns. In total, over 380 projects were completed by 75 communities and agencies as follows: CSO/SSO -88; stormwater control-47; streambank stabilization, lake restoration, and dam removal-48; public education and involvement-71; enhance river-based recreation-23; and illicit discharge elimination, water quality monitoring, other-106. *Keywords: Great Lakes basin, Rouge River, Policy making, Ecosystems.*

CHADDE, J.F.[1], PEREZ, L.J.[2], and REED, M.D.[3], [1]Michigan Technological University, 115 Great Lakes Research Center, MTU,, 1400 Townsend Dr., Houghton, MI, 49931, USA; [2]U.S. Forest Service Urban Connection, 1400 Oakman St., Detroit, MI, 48238, USA; [3]Detroit Zoological Society, 8450 W. 10 Mile Rd, Royal Oak, MI, 48067, USA. **Engaging Urban Detroit Teachers & Students in Natural Resource Stewardship.**

A year-long professional development (PD) program to build long-term teacher capacity to engage middle & high school students in stewarding urban watersheds by increasing teachers' content knowledge, pedagogical skills and confidence will be described.

Teachers become a Professional Learning Community (PLC) as they attend 8 days of PD during the school year. The project builds upon proven working relationships and an excellent track record for providing quality teacher PDWs to hundreds of Detroit teachers since 2009. A collaboration of 8+ organizations and agencies contribute to the success of the program. The goal is to sustainably provide students with access to Great Lakes Place-based Stewardship Education, including outdoor learning and stewardship work. This project empowers educators and young citizens of Detroit with the content knowledge, experiential learning, and decision-making tools to become lifelong stewards of Michigan's aquatic ecosystems. By incorporating storm drains, pervious surfaces, rain gardens, canopy trees, native species, and even puddles that students can encounter in the city, urban educators can foster systems thinking that bridges gaps across scientific, economic, political and social systems thinking. *Keywords: Public education, Stewardship, Environmental education, Teacher-training, Urban watersheds.*

CHADDERTON, W.L.[1], TUCKER, A.J.[1], ANNIS, G.[1], DAVIDSON, A.D.[2], KASHIAN, D.R.[2], HOFFMAN, J.C.[3], TREBITZ, A.S.[3], STRAKOSH, T.[4], HENSLER, S.R.[5], and LESAGE, S.[6], [1]The Nature Conservancy, South Bend, IN, 46617, USA; [2]Wayne State University, Detroit, MI, USA; [3]US EPA Mid Continent Ecology Division, Duluth, MN, USA; [4]US Fish and Wildlife Service, Atlanta, GA, USA; [5]Cerulean Center, Cedar, MI, USA; [6]Michigan Department of Environmental Quality, Lansing, MI, USA. **A Spatially Explicit Method to Inform AIS Surveillance Site Selection in the Laurentian Great Lakes.**

Choosing where to monitor for aquatic invasive species (AIS) is a daunting challenge in the Laurentian Great Lakes. Management resources are finite hence it is important that monitoring efforts concentrate on those sites with the highest risk of introduction based on transparent criteria and assumptions and the best available data. Here we describe the development of a site prioritization method designed to address such challenges. The U.S. waters of the Great Lakes and tributaries were divided into standardized management units (9 km x 9 km). An index of invasion pressure was defined using a standardized set of spatial surrogates to estimate cumulative propagule pressure for each management unit. Weighting multipliers were applied to the attributed spatial surrogate data so that both historic patterns and future predicted patterns of introduction were incorporated into the final calculation of the index of invasion pressure for each management unit. Of the total of 5,953 management units in the U.S. Great Lakes basin (land and water), about 1,800 units have attributes resulting in index scores greater than zero. The site prioritization method can be used to select surveillance priorities for fish, invertebrates, and/or plants across the U.S. waters of the Great Lakes basin. *Keywords: Invasive species, Surveillance, Risk assessment, Great Lakes basin.*

CHAFFIN, J.D.[1], BADE, D.L.[2], and KANE, D.D.[3], [1]Stone Lab Ohio State University, PO Box 119, Put-in-Bay, OH, 43456, USA; [2]Kent State University, Kent, OH, USA; [3]Defiance College, Defiance, OH, USA. **Cyanobacterial Blooms in Lake Erie's Central Basin.**

Research of cyanobacterial blooms in Lake Erie has been focused in the western basin and Sandusky Bay. However, blooms have been observed in the central basin 4 out of the last 5 summers in early July. Since 2013 we have monitored water quality at 4 fixed-location sites and conducted bloom-targeted sampling in the central basin. Dolichospermum spp. (formally Anabaena) has been the dominant cyanobacteria genera, although other phytoplankton (mostly diatoms) have outnumbered Dolichospermum. Microcystin has not been detected in blooms, except in 2 samples from July 2013 when Planktothrix co-occurred with Dolichospermum. Although Dolichospermum is a known N-fixer and is typically associated with low N and high P waters, central basin waters in July were high in nitrate and low in P. Furthermore, N-fixation has not been detected. Nutrient enrichment experiments have indicated that phytoplankton growth has been primarily P-limited in early July and then P, N, and/or trace nutrient co-limited later in summer. Additionally, the timing of blooms and hypoxia has not aligned as in some summers blooms occurred when hypolimnion oxygen was above 8 ppm and other summers blooms occurred during hypoxia. Overall, our sampling has indicated that Dolichospermum blooms occurred in early July, but the underlining drivers of the bloom remain unknown. *Keywords: Phytoplankton, Nutrients, Cyanophyta.*

CHANNELL, K.E.[1], GRONEWOLD, A.D.[2], XIAO, C.[3], ROOD, R.B.[1], LOFGREN, B.M.[2], and HUNTER, T.[2], [1]University of Michigan Climate and Space Sciences and Engineering, Ann Arbor, MI, USA; [2]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, USA; [3]Cooperative Institute for Limnology and Ecosystems Research, Ann Arbor, MI, USA. **Implications of Climate Model Debiasing Methods on Lake Level Projections.**

Numerical models can provide a basis for projecting future water levels for the Great Lakes under climate change. Hydrological components critical to generating water supplies were extracted from the WRF/GFDL-CM3 downscaled climate model, and were then used to drive a routing model to produce water levels for the 21st century. A new method of bias correction was used to provide a more consistent representation of seasonality, trends, and variability, when compared to more conventional methods. Here we demonstrate the relative differences in hydrology projections from our method and previously used methods. Our results indicate that the bias correction method used is an important source of variability in water level projections. This is a source of variability that is perhaps just as important as choice of models, emission scenarios, etc., but is commonly overlooked. *Keywords: Water level, Climate change, Modeling.*

CHAUDHARY, A., TURNER, S., MACAM, R., and PORETSKY, R., University of Illinois at Chicago, 1200 W Harrison Street, Chicago, IL, 60607, USA. **Lake Michigan bacterioplankton metagenomics and response to allochthonous dissolved organic matter.**

Freshwater bacterioplankton play important ecological and biogeochemical roles by production and assimilation of dissolved organic matter(DOM). They are highly sensitive to changes in nutrient regimes, which is critical as human activities shift carbon dynamics in freshwater ecosystems. Here, we explored the taxonomic and functional diversity of bacterioplankton inhabiting Lake Michigan, and their responses to pulses of terrestrially-derived DOM (leaf litter extract). Water samples were collected along a coastal-to-offshore transect with a natural DOM gradient beginning at the mouth of Kalamazoo River. Analysis of the native bacterial community using metagenomics revealed the nearshore and offshore communities to be composed of known freshwater taxa with similar relative abundances, although certain taxa (Pelagibacteria, Acidimicrobiales) differed in their relative abundance across the transect, and the nearshore community exhibited a higher alpha diversity. Microcosms from these samples were amended with terrestrially-derived DOM (t-DOM), along with an unamended control and subsampled at 2h and 19h to analyze the bacterial response to t-DOM using 16S rRNA gene and mRNA sequencing. Results revealed differential responses of the nearshore and offshore bacteria to t-DOM, indicating different adaptations to processing this carbon. *Keywords: Microbiological studies, Lake Michigan, Dissolved organic matter.*

CHAVARIE, L.[1], HARFORD, W.[2], HOWLAND, K.[3], MUIR, A.[4], KRUEGER, C.C.[5], and TONN, W.[6], [1]Michigan State University, East Lansing, MI, USA; [2]Cooperative Institute of Marine & Atmospheric Studies, University of Miami, Miami,, FL, USA; [3]Freshwater Institute, DFO, Winnipeg, MT, CANADA; [4]Great Lake Fishery Commission, 2100 Commonwealth Blvd, Suite, Ann Arbor, MI, 48105, USA; [5]Michigan State University, East Lansing, MI, USA; [6]Michigan State University, University of Alberta, Edmonton, AB, USA. **Generalist morphs of Lake Trout: Avoiding constraints on the evolution of intraspecific divergence?**

To better understand how resources may be partitioned in a northern system that supports intraspecific diversity of Lake Trout, trophic niches were compared among four shallow-water morphotypes in Great Bear Lake. Bayesian mixing model analyses of stable isotopes of carbon and nitrogen were conducted on adult Lake Trout. Major niche overlap in resource use among four Lake Trout morphotypes was found, which raises the question how such polymorphism can be sustained among opportunistic generalist morphotypes. Covariances of our morphological datasets were tested against δ13C and δ15N values. This link between ecological and morphological differentiation suggested that selection pressure operate at the trophic level, independent of habitat, rather than along the habitat-foraging opportunity axis. The spatial and temporal variability of resources in Arctic lakes, such as Great Bear Lake, may have favored the presence of multiple generalists showing different degrees of omnivory along a weak benthic-pelagic gradient. Evidence for frequent cannibalism in Great Bear Lake was found across all four morphotypes, and may also contribute to polymorphism. We suggest that the multiple generalist morphs described here from Great Bear Lake is a unique expression of diversity due to the presumed constraints on the evolution of generalists. *Keywords: Arctic, Generalist-specialist, Fish, Great Bear Lake, Stable isotopes, Polymorphism.*

CHENERY, E.S.[1], DRAKE, D.A.R.[2], and MANDRAK, N.E.[1], [1]University of Toronto Scarborough, Toronto, ON, CANADA; [2]Fisheries and Oceans Canada, Burlington, ON, CANADA. **Forecasting Secondary Spread of AIS in the Great Lakes Using Expert Opinion and Mechanistic Models.**

Predicting the spatial and temporal dynamics of spread for newly established invasive species is critical for informing successful management intervention. However, demographic data required for comparing different population trajectories of AIS is rare, resulting in substantial uncertainty in spread projections. A novel approach to quantifying uncertainty combines mechanistic modeling of the spread process with expert opinion to inform key population parameters. A Structured Expert Judgment survey was completed by 24 taxonomic experts, covering 60 species established in the GLB. Experts estimated a range of species-specific demographic parameters that were incorporated within an existing mechanistic model of human-mediated spread involving interactions between species and their vectors of movement (Laker ballast). Spread was calculated as a rate allowing for spatiotemporal comparison of spread potential across all taxonomic groups. Expert judgments led to a wide range of spread rates estimated by the model, and comparisons across all groups showed that, without management intervention, most AIS could saturate the GLB in <10 years. This process improves upon traditional management 'best-guess' approaches through its structured treatment of uncertainty, allowing standardization of comparisons between likely spread scenarios. *Keywords: Structured Expert Judgment, Great Lakes basin, Mechanistic models, Invasive species, Ballast.*

CHENG, F.C., VAN METER, K.J., and BASU, N.B., University of Waterloo, 200 University West, Waterloo, ON, N2l 3G1, CANADA. **Biogeochemical Hotspots: Role of Small Water Bodies on Regional Nutrient Processing.**

Lentic sytems such as lakes, reservoirs, and wetlands are able to retain nitrogen (N) and phosphorus(P), thus regulating their delivery to downstream waters. While the processes controlling N and P retention are relatively well-known, there is a lack of quantitative understanding of how these processes manifest across spatial scales. We synthesized data from 600 sites across the world and various system types to gain insight into the relationship between hydrologic and biogeochemical controls on nutrient retention. Our results indicate that the first-order reaction rate constant, k, is inversely proportional to the hydraulic residence time, τ, across six orders of magnitude in residence time for total N, total P, nitrate, and phosphate. We proposed that the consistency of the relationship points to a strong hydrologic control on biogeochemical processing, and validated our hypothesis using a sediment-water model that links major nutrient removal processes with system size. Finally, the k-τ relationships were upscaled to the landscape scale using a wetland size-frequency distribution. Results highlight the disproportionately large role of small wetlands in landscape scale nutrient processing. Thus, for the same wetland area lost, the nutrient removal potential lost is larger when smaller wetlands are removed. *Keywords: Wetlands, Lakes, Nutrients.*

CHENG, V.[1], JAVED, A.[1], KIM, D.K.[1], NEUMANN, A.[1], RICHARDS, A.[2], and ARHONDITSIS, G.B.[1], [1]University of Toronto Scarborough, 1265 Military Trail, Toronto, ON, M1C1A4, CANADA; [2]Environment and Climate Change Canada, Burlington, ON, USA. **Relationship between large-scale climate indices, local climate variability and lake levels of Lake.**

Numerous studies have attempted to connect Great Lakes water levels to potential large-scale climate modes, but few studies have attempted to link large-scale climate indices to the intermediate meteorological and hydrological processes which are the main drivers of the lake level fluctuations. In this study, we examine possible linkages between multiple climate indices (Artic Oscillation-AO, North Atlantic Oscillation-NAO, Ocanic Niño Index-ONI, East Pacific-North Pacific index-EP-NP, Tropical Northern Hemisphere index TNH, Southern Oscillation Index-SOI, Multivariate ENSO Index-MEI, Pacific Decadal Oscillation-PDO, Pacific North American Index-PNA, Atlantic Multidecadal Oscillation index-AMO) to the monthly average Lake Huron-Michigan meteorological and hydrological variables (air temperature, precipitation, lake temperature, wind speed and direction, sea level pressure, evaporation, runoff). For precipitation, it is found that sea level pressure, zonal and meridional wind were the primary drivers, while PNA, TNH, EP-NP and PDO were

secondary drivers. For evaporation, ice cover, air and water temperature were the primary predictors as anticipated. Zonal wind was also a good predictor during winter and fall. EP-NP and ENSO indices all have secondary roles. *Keywords: Lake Huron, Hydroclimate, Water level fluctuations, Lake Michigan, Atmospheric circulation.*

CHIANDET, A.S., SHERMAN, R.K., LESPERANCE, C.T., MCPHAIL, A.K., and MADILL, P.M., Severn Sound Environmental Association, 67 Fourth St., Midland, ON, L4R 3S9, CANADA. **How and why do local climate signals vary in different ways? A case study in Severn Sound, Georgian.**

Many different indicators are used to examine the effect of climate change on aquatic and terrestrial systems, including water and air temperature, ice cover, length of stratified season, etc. Data for various climate change indicators were compiled and analyzed for the Severn Sound area of Southeastern Georgian Bay, some with over 100 years of data. Some indicators showed significant trends that would point to climate change impacts and some did not. For example, trend analysis showed that mean surface ice free season temperature increased significantly in the Severn Sound open waters (n=45 yrs, p<0.05) and that the most important contributor to this increase was temperature in early October, for which there was an increase at double the rate for mean temperature. This pattern was also true of air temperatures (n=38 yrs). In contrast, analysis of changes in ice phenology on embayments in Severn Sound and local inland lakes showed no significant monotonic trends (n ranged 12-99 yrs). This work demonstrates that not all climate signals vary in the same way, pointing to the importance of a) understanding how indicators interact with each other through space and time, and b) using multiple lines of evidence to describe climate change impacts.
Keywords: Climate change, Long term trends, Georgian Bay, Severn Sound, Citizen science, Indicators.

CHILD, M.M.[1] and DEMPSEY, D.D.[2], [1]International Joint Commission, 100 Ouelette Avenue, Windsor, ON, N9Y 6T3, CANADA; [2]formerly International Joint Commission, 2000 L Street NW, Washington, DC, 20036, USA. **Binational Areas of Concern - Symmetry or Solitude?**

Of the 43 Areas of Concern identified to date, five are binational. For those AOCs, two parallel and interactive domestic processes are in place, although progress towards completion of management actions is generally uneven between those domestic processes. This session will provide an overview of binational AOCs and examine challenges and opportunities unique to them. Issues that will be addressed include their historical context, adoption of the ecosystem approach, harmonization of delisting and beneficial use impairment criteria, and coordination of monitoring, management actions and public engagement activities. This session is particularly timely since management actions have been completed on one side of several of the binational AOCs, and therefore delisting approaches are under active consideration. *Keywords: Areas of Concern, Binational.*

CHOI, O., LEI, L., and SEO, Y., The University of Toledo, 2801 W. Bancroft Street, Toledo, OH, 43606, USA. **Characteristics of Chlorination Disinfection Byproducts Formation of Neuro-Cyanotoxic Amino Acids.**

Neuro-cyanotoxic amino acids (NCAAs) among cyanotoxins have come under intense research over the last decade, as they have been reported to cause neurodegenerative diseases such as amyotrophic lateral sclerosis and Alzheimer's disease, etc. Hence, it is very important to remove NCAAs from drinking water to protect the public from unwanted exposure to the harmful toxins. Chlorine is used as a primary disinfectant in many water treatment plants and many previous studies reported that chlorine is an excellent oxidant to remove cyanotoxin in water. However, NCAAs could act as the precursors of disinfection by-products (DBPs) during chlorination. This study investigated DBPs formation and the formation pathway of NCAAs during chlorination. NCAAs produced high level of nitrogenous DBPs (N-DBPs) including dichloroacetonitrile (DCAN), trichloroacetonitrile (TCAN). Formation pathways of N-DBPs (DCAN and TCAN) were tentatively proposed during chlorination of NCAAs. The chemical structures of the intermediates during the chlorination of NCAAs were identified using triple-quadrupole mass spectrometer. The content of the formed intermediates under different chlorine dosages was also investigated to further illustrate the reasonability of the hypothesized reaction pathways. *Keywords: Toxic substances, Disinfection by-product, Algae, Water quality.*

CHOITTI, J.A.[1], ROSEMAN, E.F.[2], BOASE, J.C.[1], DEBRUYNE, R.L.[2], DROUIN, R.[3], KNIGHT, R.L.[4], and SELZER, M.D.[5], [1]U.S. Fish and Wildlife Service, Alpena FWCO - Waterford Substation, 7806 Gale Rd., Waterford, MI, 48327, USA; [2]U.S. Geological Survey, Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105, USA; [3]Ontario Ministry of Natural Resources and Forestry, Lake Erie Management Unit, 4th Floor, 659 Exeter Road, London, ON, N6E 1L3, USA; [4]Great Lakes Fishery Commission, 2100 Commonwealth Blvd, Ann Arbor, MI, 48105, USA; [5]Michigan Department of Environmental Quality, Michigan Office of the Great Lakes, 525 West Allegan Street, Lansing, MI, 48909, USA. **The St. Clair - Detroit River System Initiative Science and Monitoring Strategy.**

The St. Clair-Detroit River System Initiative (SCDRSI) is an interdisciplinary initiative that has evolved to serve as a governance structure guiding decision-making and communication through a network of collaborating scientists and stakeholders. To measure progress toward a common agenda of restoring ecosystem integrity, a science and monitoring strategy has been developed based on priority objectives identified by the Initiative. In order to measure progress in achieving priority objectives, physical and biological/response indicators were developed through workshops with the SCDRSI membership, guidance from experts, and linkages with established broader scale environmental objectives. Monitoring programs within the SCDRS have been inventoried and provide the foundation for indicator assessment. In some cases, indicators were identified as important; however some lack a clear monitoring program and long-term assessment. These knowledge and monitoring gaps will influence the science strategy for future research in the SCDRS. Ongoing monitoring and research projects have been cataloged in an online database informing SCDRS membership. Collaboration between partners within the SCDRSI serves to reduce effort duplication and increase monitoring and restoration efficiency on this large Great Lakes connecting channel. *Keywords: Bioindicators, St. Clair - Detroit River System, Connecting channels.*

<u>CHOU, N.</u>, MALINICH, T.D., and HÖÖK, T.O., Purdue University, 195 Marsteller St, West Lafayette, IN, 47906, USA. **Let Minnow if you Find Micro-Plastics.**

Micro-plastic particles are prevalent within the Great Lakes and other bodies of water throughout the world. Their high densities suggest frequent encounters with fish foragers. Due to their small size, micro-plastics may be consumed by larval fish. In turn, such consumption could lead to various deleterious effects, including decreased consumption of natural prey and reduced growth. We tested the consumption of two age groups (7 day, 14 day) of fathead minnows, Pimephales promelas, when exposed to 2 sizes of micro-plastic beads (18 µm, 50 µm) and a natural food source (Artemia spp.). Finding no consumption of beads in these trials, we then considered potential non-consumptive effects of micro-plastics by raising larvae (for 15 or 30 days) with natural prey at three density levels of micro-plastic beads (18 µm). An analysis of stomach contents of larvae revealed that some minnows had consumed plastic beads. However, no effect on consumption of natural prey was detected and growth and survival rates did not differ among treatments. We suggest that future experiments should test for differences in foraging behaviors between different fish species as well as between different types of plastic particles (i.e. fibers vs beads) that may be encountered. *Keywords: Microplastics, Larval Fish, Fish behavior.*

<u>CHU, P.</u>, ANDERSON, E.J., LOFGREN, B.M., GRONEWOLD, A.D., WANG, J., STOW, C.A., LANG, G.A., HUNTER, T., and CLITES, A., NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Road, Ann Arbor, MI, 48108, USA. **Towards an Integrated Environmental Modeling System for the Great Lakes.**

NOAA Great Lakes Environmental Research Laboratory (GLERL) has been providing water level, hydrological and ice cover data since the 1980's and lake currents, temperature and wave forecasts since the 1990's. However, in most cases the models have been operated in a stand-alone fashion with no interactions between models. There's a need to integrate individual models (atmosphere, hydrodynamics, watershed hydrology, wave, ice, and ecological) to properly represent the physics and account for the energy or momentum exchange interactions at the air-water-land interface. Builing on the success of NOAA Great Lake Operational Forecast system and the newly operational National Water (hydrology) Model, the modeling group at GLERL is developing and testing an integrated coupled modeling system that allows information exchange between models through a coupling framework. The climate-land-lake, atmosphere-hydrodynamics, hydrology-hydrodynamics, hydrodynamics-ice, hydrodynamics-wave and hydrodynamics-ecology coupling mechanisms have been developed and are currently undergoing validation and verification. Once the optimal coupling strategy and frequency is found, data assimilation and ensemble forecasting techniques will be incorporated into the system to improve the forecast accuracy and reduce uncertainty. *Keywords: Hydrodynamic model, Model coupling, Modeling, Data assimilation, Great Lakes basin, Ice modeling.*

CIECIEK, C.[1], KOCH, K.[1], DIXON, D.[2], and BLACK, J.[2], [1]LimnoTech, 501 Avis Dr., Ann Arbor, MI, 48108, USA; [2]Electric Power Research Institute, Inc, 3420 Hillview Avenue, Palo Alto, CA, 94304, USA. **Internet-Based Larval Fish and Egg Taxonomic Key Resources for Freshwater and Marine Environments.**

Access to and utility of traditional hardcopy taxonomic fish keys is sometimes limited by availability, new species, corrections and costs, forcing scientists to rely on multiple, sometimes outdated keys. Web-based key platforms can provide greater access to these important resources and allow flexibility for updates, high-resolution images, and greater identification precision. With funding support from the Electric Power Research Institute (EPRI), a collaborative effort was undertaken to develop open-access, web-based versions of seminal taxonomic keys used for freshwater and marine environments built on the Lucid taxonomic key software platform. Print resources used were: Freshwater > *Identification of Larval Fishes of the Great Lakes ...* (Auer, 1982); Atlantic near-shore incorporated three publications > *Early Stages of Atlantic Fishes...* (Richards, ed. 2005), *Fishes of the Western North Atlantic... Leptocephali* (Bohlke, 1989), and *Development of fishes of the Mid-Atlantic Bight...* (USFWS, 1978); and the Pacific > *The Early Stages of Fishes in the California Current Region CALCOFI/...* (Moser, ed. 1996). This presentation will describe and provide a demonstration of the online keys and discuss their value relative to supporting early life stage taxonomic activities. *Keywords: Early life stage taxonomy, Taxonomic keys, Fish, larval and eggs.*

CLAPP, D.F., Michigan DNR - Charlevoix Fisheries Research Station, 96 Grant Street, Charlevoix, MI, 49720, USA. **A Finger on the Pulse of Fisheries: Making Connections Through Space and Time.**

From high school, to the University of Michigan, to my current position with the Michigan DNR, personally and professionally Jim Diana has had an enormous impact. At UM, Jim facilitated my working with some giants in the field, and introduced me to research ideas (regulation issues, telemetry) that have had a recurring place in my career. I also got to know some of Jim's best traits - high expectations, giving students the freedom to range widely in pursuit of answers, excellent editing ability, a great sense of humor, and an even greater sense of priorities. In Florida and then Illinois, I worked on issues related to fish movement, esocid population dynamics, and energetics - all areas that I was well prepared to tackle as a result of Jim's mentorship. Returning to a dream job in Michigan, I found myself again working on issues (salmon foraging, alewife dynamics) that overlapped extensively with Jim's expertise and the training he provided. Throughout my entire career, Jim has remained a steadfast mentor, confidant, and friend. Whether making sure I have great seats for the UM-OSU game or advising me on career decisions, he's always been there. In serving this same role for dozens of Great Lakes professionals, Jim has had a profound effect on fisheries research and management. *Keywords: Fisheries, Great Lakes basin.*

CLARAMUNT, R.M.[1], HERBERT, M.[2], CHADDERTON, W.L.[3], TUCKER, A.J.[3], GALAROWICZ, T.L.[4], CLAPP, D.F.[5], and CALABRO, E.[5], [1]Michigan DNR, 8258 S. Ayr Road, Alanson, MI, 49706, USA; [2]The Nature Conservancy, 101 East Grand River Ave, Lansing, MI, 48906, USA; [3]The Nature Conservancy, 1400 E. Angela Blvd, South Bend, IN, 46617, USA; [4]Central Michigan University, Biosciences 2100, Mt. Pleasant, MI, 48859, USA; [5]Michigan DNR, 96 Grant Street, Charlevoix, MI, 49720, USA. **The Next Frontier in Great Lakes Fisheries Habitat: Building Criteria for Spawning Reef Restoration.**

Fisheries habitats in the Great Lakes function at a large spatial scale and linkages with fish populations are difficult to characterize. There has been work on identifying reefs, shoals, or habitat complexes that are especially important as fish spawning and nursery grounds. These critical in-lake habitats face ongoing threats from invasive species (mussels, round gobies, rusty crayfish), climate driven changes (increased physical forces and water level fluctuations), and direct degradation (dredging and shoreline development). When the habitat is not optimal or has been degraded, rehabilitation can be difficult because historical benchmarks, in terms of habitat quality and functionality, are typically not available to inform restoration strategies. Instead, much of Great Lakes habitat restoration work is focused on managing inputs, such as tributaries, connected watersheds, or the coastal interface. We report on a case study that restored habitat quality on a degraded reef to a

condition similar to reference sites in an adjacent reef complex, demonstrating that reef restoration is achievable and can be linked with benefits to fish recruitment. From that study, we developed a list of criteria to inform future reef rehabilitation projects and will demonstrate how they can be applied to other reefs in lakes Huron and Michigan.
Keywords: Fisheries, Reefs, Habitats, Recruitment.

CLARK, R.[1], JONES, M.[1], BENCE, J.R.[1], MADENJIAN, C.P.[2], WARNER, D.[2], CLARAMUNT, R.M.[3], WRIGHT, G.[4], TSEHAYE, I.[5], LEGLER, N.[5], ROBILLARD, S.[6], and DICKINSON, B.[7], [1]Quantitative Fisheries Center, Michigan State University, East Lansing, MI, 48824, USA; [2]U.S. Geological Survey, Great Lakes Science Center, Ann Arbor, MI, 48105, USA; [3]Michigan Department of Natural Resources, Oden State Fish Hatchery, Alanson, MI, 49706, USA; [4]Sault Ste Marie Tribe of Chippewa Indians, Hessel, MI, 49745, USA; [5]Wisconsin Department of Natural Resources, Madison, WI, 53703, USA; [6]Illinois Department of Natural Resources, Des Plaines, IL, 60016, USA; [7]Indian Department of Natural Resources, Michigan City, IN, 46360, USA. **Using Predator-Prey Ratio to Manage a Balance between Chinook Salmon and Alewives in Lake Michigan.**

The trophic pyramid is among the oldest concepts in ecology. It suggests that food webs can be organized into a series of levels in which matter and energy are transferred from lower (prey) to upper (predator) levels. The predator-prey ratio (PPR) has often been used as a measure of the transfer rate between levels, and many laboratory, field, and modeling studies have shown that PPRs have a limited range of sustainable values of 0.05-0.15. We developed a tool to estimate past, present, and future Chinook Salmon-Alewife PPRs in Lake Michigan. We estimated Chinook Salmon abundance by age by fitting the annual time series' of fishing effort, catch at age, and stocked and natural recruitment. We estimated Alewife abundance by age by fitting the annual time series' of trawl survey catches, hydroacoustic survey estimates, and predator consumption estimates. We estimated biomasses by multiplying abundances and weights at age and estimated PPR as Chinook/Alewife biomass. We identified target and limit reference points for PPRs to help guide salmonine stocking policies. The tool continues to be a work in progress, but it has contributed to decisions regarding stocking of Chinook Salmon and other salmonines in Lake Michigan for the past three years. *Keywords: Alewife, Ecosystem modeling, Salmon.*

COLBORNE, S.F.[1], KLINARD, N.V.[1], KESSEL, S.T.[2], HALFYARD, E.A.[3], and FISK, A.T.[1], [1]Great Lakes Institute for Environmental Research - University of Windsor, Windsor, ON, CANADA; [2]Department of Fisheries and Wildlife, Michigan State University, East Lansing, MI, USA; [3]The Nova Scotia Salmon Association, Beaver Bank, NS,

CANADA. **Fish Movement in Urban Ecosystems: Using Acoustic Telemetry to Monitor Fish in the Detroit River.**

Urbanization has significantly altered freshwater habitats through numerous direct and indirect means on a global scale. Recent efforts in conservation and management practices are working to balance the ecological health of systems with human activities. A thorough understanding of how fish use the available habitat can be linked to ecological characteristics that are informative for management, e.g. identify foraging patches. We used passive acoustic telemetry in the Detroit River to monitor the movements of piscivores, bowfin (*Amia calva*) and largemouth bass (*Micropterus salmoides*), and forage fish, sunfish (*Lepomis gibbosus* and *L. macrochirus*). Using a focal array consisting of 26 stations and broad scale coverage through the GLATOS network we have monitored fish movement since June 2015. We found that all tagged fish showed infrequent movements across a shipping channel, moving along the edges of the channel rather than crossing it during summer and autumn months. Both piscivores exhibited site fidelity, including 20 fish (12 bowfin, 8 largemouth bass) returning between years. The ecological information about habitat use from this study is providing insights into the ecology of fishes in this urban river environment and is applicable to ongoing restoration efforts. *Keywords: Acoustics, Urbanization, Detroit River.*

COLE, S.J., Great Lakes Commission, 2805 S Industrial Hwy, Suite 100, Ann Arbor, MI, 48104, USA. **Human Uses of Great Lakes - St. Lawrence Water: What We Know and Don't Know.**

For twenty years, the Great Lakes and St. Lawrence River states and provinces have submitted water use data to a database managed by the Great Lakes Commission to support the Great Lakes and St. Lawrence River Water Resources Compact and Agreement. This data includes withdrawals, consumptive uses and diversions by type of use, water source, jurisdiction and watershed. Each year, the GLC compiles and summarizes these datasets into an annual report. The GLC, in partnership with water use managers from the states and provinces, continues to assess ways to improve data quality and the collective understanding of water uses in the region. This presentation will describe how water was used in the region during 2015, what we understand about water use in the basin overall and outline some research priorities to fill knowledge gaps. *Keywords: Hydrologic budget, Water use, Lake management, Consumptive use, Monitoring, Diversions.*

COLLIER (SHERMAN), J.J., CRAIL, T., and BOSSENBROEK, J.M., University of Toledo, Department of Environmental Sciences, 2801 W. Bancroft St., Toledo, OH, 43606,

USA. **Using Habitat Suitability Index Models to Locate Freshwater Mussel Communities in the Maumee River.**

A Habitat Suitability Index model was created to predict presence and absence of freshwater mussel (unionid) communities in the lower Maumee River. Substrate, water depth, and water velocity were assessed and integrated into suitability index values to delineate good, moderate, and poor habitat. Substrate and water depth were surveyed using side-scan sonar while water velocity was modeled with HEC-RAS software. Each habitat characteristic was mapped as a spatially explicit layer in ArcGIS and then combined to provide an overall assessment of habitat suitability. Field surveys were conducted at 34 sites to evaluate how the model performed predicting the presence and absence of unionid communities. Preliminary results indicate the model could not accurately predict unionid presence or absence based on the delineation of habitat and there was no significant difference in either species abundance or richness. We suspect the model outputs need to be refined to predict habitat at smaller spatial scales or patch sizes. This model is in the first stages of development and through feedback and parameter refinement, it has the potential to provide a useful tool for researchers and managers to survey and monitor the status of unionid populations. *Keywords: Model testing, Habitats, Rivers, Unionids.*

COLOMBO, S.M., ARTS, M.T., ZHALAN, F., and KOPRIVNIKAR, J., Ryerson University, 350 Victoria Street, Toronto, ON, CANADA. **Fatty acid analysis as a tool to understand parasitism in Rock Bass and Smallmouth Bass.**

Fatty acids (FA) were used as biomarkers to understand how the diet and health of two fish species (Rock Bass and Smallmouth Bass) influences their susceptibility and tolerance to parasitism. As Rock Bass are recently established in some Ontario lakes relative to Smallmouth Bass, they should have a lower diversity and intensity of parasite infections. The use of FA analysis will help understand if this difference is driven by fish host ecology, or adaptability of the parasites. FA are useful tracers to approximate the diet and trophic position of an individual. The diet of the fish host influences the overall health of the individual, which subsequently impacts their susceptibility to infection and survivability post-infection. Optimal ratios of EPA, DHA, and ARA, as well as the omega-3/omega-6 ratio are useful biomarkers of health. Trophic position is a strong predictor of parasitism, as consumption of infected prey influences susceptibility to infection. Fish were examined for the presence of trophically-transmitted helminths, fish morphology, gut content, and FA analysis of the muscle tissue. The relationship between parasitism and host FA content may help understand and predict parasitic infection in other fish species, which may be useful in fisheries management and aquaculture. *Keywords: Parasites, Fatty acids, Fish.*

CONARD, W.M.[1], GERIG, B.S.[1], LOVIN, L.M.[1], BUNNELL, D.B.[2], and LAMBERTI, G.A.[1], [1]University of Notre Dame, Department of Biological Sciences, Notre Dame, IN, USA; [2]United States Geological Survey, Great Lakes Science Center, Ann Arbor, MI, USA. **Heavy Metal Concentrations in Lake Michigan Prey Fish.**

Understanding factors governing bioaccumulation of heavy metals in Great Lakes fish is important for ecosystem and human health. For instance, mercury bioaccumulates in piscivorous fish, but trophic pathways leading to bioaccumulation remain poorly understood. To address this uncertainty, we examined heavy metal tissue concentrations in Lake Michigan prey fish that differ in life history traits and trophic position. Six Lake Michigan prey species from the 2015 USGS trawl survey were included - *Myoxocephalus thompsoni*, *Cottus cognatus*, *Coregonus hoyi*, *Alosa pseudoharengus*, *Osmerus mordax*, and *Neogobius melanostomus*. We measured stable isotope ratio (δN15 and δC13), tissue metal concentration (mercury, lead, copper, nickel, zinc, cadmium), and individual fish attributes (total length, weight, body condition, capture depth and location). We observed differences in tissue metal concentration between nearshore and offshore and between benthic and pelagic species but patterns varied among metals. Overall, mercury exhibited strong positive positively correlation with trophic position (δN15 and δC13) but the magnitude of the effect varied among species. Based upon AICc, species identity and total length best explained mercury concentration (multiple $R2=0.82$, $p<0.01$). *Keywords: Lake Michigan, Prey fish, Heavy metals.*

CONKLIN, A.R.[1] and SEILHEIMER, T.S.[2], [1]Wisconsin Sea Grant, 1975 Willow Drive, Madison, WI, 53706, USA; [2]Wisconsin Sea Grant, 705 Viebahn St, Manitowoc, WI, 4220, USA. **The @DrFishSG is in: improving the great lakes through #outreach and #scicomm.**

Social media is about so much more than just taking and sharing pictures of your food--it's also a diverse, powerful and even-expanding tool that can connect you with the audiences that care about your scientific research. Even though you've only got a mere 140 characters to work with--don't forget the pictures! - it's possible to reach and interact with thousands of people who care about your science several times a day. Science communication (#scicomm) through social media is a useful tool for reaching a wide audience and engaging them in both conversation and action. Building that network and reach takes time and strategy, as well as patience and consistency, but it doesn't have to be scary and it doesn't have to consume your life. Through examples and best-management practice tips, we'll demonstrate the most effective ways to harness #scicomm through social media, so you can extend your reach, make your science actionable, and help improve the #GreatLakes. *Keywords: Environmental education, Outreach.*

CONNOLLY, J.K.[1], WATKINS, J.M.[1], WARREN, G.J.[2], and RUDSTAM, L.G.[1], [1]Cornell University, Department of Natural Resources, 110 Fernow Hall, Ithaca, NY, 14853, USA; [2]US Environmental Protection Agency, Great Lakes National Program Office (US EPA GLNPO), 77 W. Jackson Blvd., Chicago, IL, 60604, USA. **Non-Native cyclopoid copepod (*Thermocyclops crassus*) detected in Lake Erie.**

The first non-native zooplankton species (*Thermocyclops crassus*) detected in the Great Lakes since 2006 was made as a result of the EPA GLNPO monitoring program. *T. crassus* , a cyclopoid copepod with a large geographic range in Eurasia and Africa, was detected in western Lake Erie in 2014. After its initial detection, *T. crassus* was also collected in western Lake Erie in the summers of 2015 and 2016. While *T. crassus* densities remained low between 2014-2016 a range expansion across the western basin of Lake Erie was observed. While some members of the genus Thermocyclops (*T. parvus, T. tenuis,* and *T. inversus*) are native to regions of the southern United States, *T. crassus* is considered introduced. *T. crassus* has been reported on three isolated occasions in the western hemisphere, in ponds of San José province, Costa Rica, and Tabasco state, Mexico, and in Missisquoi Bay, Lake Champlain, Vermont, USA. The Lake Champlain and Lake Erie *T. crassus* detections are separated by 23 years and in both cases the means of introduction remains unclear. No species of Thermocyclops are native to the Great Lakes but *Mesocyclops edax* a common native copepod from a closely related genus may be confused for *T. crassus*, morphological differences will be described. *Keywords: Zooplankton, Exotic species, Lake Erie.*

COOK, C.[1] and VERHAMME, E.M.[2], [1]University of Wisconsin Extension, 625 E. County Road Y, Suite 600, Oshkosh, WI, 54901, USA; [2]LimnoTech, 501 Avis Dr, Ann Arbor, MI, 48108, USA. **State of Lake Michigan Fall 2017 Conference.**

This presentation will focus on the State of Lake Michigan meeting to be held in Green Bay Wisconsin in November 2017. The presentation will highlight the history of State of Lake Michigan and how a new partnership with IAGLR will help in sustaining this conference. *Keywords: Lake Michigan.*

COOPER, M.J.[1], BRADY, V.J.[2], UZARSKI, D.G.[3], LAMBERTI, G.A.[4], MOERKE, A.H.[5], RUETZ, C.R.[6], WILCOX, D.A.[7], CIBOROWSKI, J.J.H.[8], GATHMAN, J.P.[9], GRABAS, G.P.[10], and JOHNSON, L.B.[2], [1]Northland College, Ashland, WI, USA; [2]Natural Resources Research Institute, University of Minnesota Duluth, Duluth, MN, USA; [3]Central Michigan University, Mount Pleasant, MI, USA; [4]University of Notre Dame, Notre Dame, IN, USA; [5]Lake Superior State University, Sault Ste. Marie, MI, USA; [6]Grand Valley State University, Muskegon, MI, USA; [7]College at Brockport, Brockport, NY, USA; [8]University of Windsor, Windsor, CANADA; [9]University of Wisconsin-River Falls, River Falls, WI, USA;

[10]Environment and Climate Change Canada, Toronto, CANADA. **An Expanded Fish-Based Index of Biotic Integrity for Great Lakes Coastal Wetlands.**

Biotic indicators are useful for assessing ecosystem health because the structure of resident communities generally reflects abiotic conditions integrated over time. We used fish data collected over three years for 254 Great Lakes coastal wetlands to develop multi-metric indices of biotic integrity (IBI). Sampling and IBI development were stratified by vegetation type within each wetland to account for differences in physical habitat. Metrics were evaluated against numerous measures of human disturbance derived from water quality and surrounding landscape variables. IBIs were composed of 10-15 metrics for each of four vegetation types (bulrush, cattail, water lily, and submersed aquatic vegetation). The IBIs have been calculated for 424 wetlands sampled from 2011 to 2015 and resulting IBI scores generally correlated well with water quality and landscape-based estimates of human disturbance. Our fish IBIs can be used with other indicators to prioritize protection and restoration efforts across the Great Lakes basin and to track conditions over time. The IBIs may also be useful in monitoring programs mandated by the bi-national Great Lakes Water Quality Agreement, such as assessing Beneficial Use Impairments in Great Lakes Areas of Concern, or in other ecosystem management programs. *Keywords: Fish, Bioindicators, Wetlands.*

CORCORAN, P.L., RYAN, K., and BAZAL, S., University of Western Ontario, 1151 Richmond St. N., London, ON, N6A5B7, CANADA. **Microplastics in Bottom Sediments of the Thames River, Ontario.**

Bottom sediments of the Thames River, Ontario, were sampled to determine abundances, distribution and types of microplastics in urban and rural regions. Using a Petite Ponar grab sampler, 13 samples were collected from between Mitchell and London; 4 from between Tavistock and Thamesford; 8 from between Innerkip and London; and 9 from between London and Lighthouse Cove. The samples were processed in the Sample Separation Laboratory (Earth Sciences) at Western University. Each sample was weighed, dried, and then mixed with a sodium polytungstate (SPT) solution of 1.5 g/cm3. The samples were magnetically stirred, then poured into a separatory funnel through which grains with densities >1.5 g/cm3 and <1.5 g/cm3 were drained onto 25 µm filter paper. The lower density fraction was rinsed with distilled water through a 0.053 µm sieve and was emptied into a petri dish for visual identification using a stereomicroscope at magnifications of 15x-225x. Randomly selected microplastic particles were prepared for analysis by Fourier Transform Infrared Spectroscopy (FTIR).Preliminary results show that the main microplastic particles are fibres, with lesser amounts of fragments and microbeads. Initial numbers suggest that the total microplastics identified in each sample is affected by

proximity to urban centres. *Keywords: Distribution patterns, Bottom sampling, Thames River, Microplastics.*

COY, S.R.[1], GANN, E.R.[1], GIBSON, C.M.[1], SUN, X.[1], HOLDER, M.E.[2], AJAMI, N.J.[2], PETROSINO, J.F.[2], VAN ETTEN, J.L.[3], CAMPAGNA, S.R.[1], and WILHELM, S.W.[1], [1]University of Tennessee, Knoxville, TN, USA; [2]Alkek Center for Metagenomics and Microbiome Research, Houston, TX, USA; [3]University of Nebraska, Lincoln, NE, USA. **Chlorovirus methylation: a model for elucidating epigenomic functions in large dsDNA viruses.**

Chloroviruses and their green algal hosts are the model system for studying eukaryotic algal host-virus interactions in fresh waters. A unique feature of chloroviruses is a diverse collection of methyltransferases, with some strains devoting > 4% of their protein coding potential towards these genes. Characterization of the methylation patterns generated by these proteins can provide insight into the function(s) of DNA modifications in algal-infecting viruses. We aimed to characterize the function(s) of chlorovirus methylation from two perspectives: i) by repeating UPLC-MS experiments to determine temporal stability of genomic methylation, and ii) by determining site specific modifications by single molecule real time (SMRT) sequencing. Preliminary *in-silico* 'potential' methylation patterns, generated by mapping functionally determined motifs unto chlorovirus genomes, indicate regions of hyper- and hypo- methylation, with some functional gene classes exhibiting significantly higher methylation potential. Pair-wise analyses of SMRT sequenced genomes allow for a high-resolution test of the conservation of methylation patterns. These results will be discussed in the context of epigenomic stability, function, and ecological implications of DNA modifications in viruses that infect eukaryotic algae. *Keywords: Methylation, Algae, Viruses.*

COYLE, B.P.[1], MCNAUGHT, A.S.[1], ROSEMAN, E.F.[2], KEELER, K.M.[2], DEBRUYNE, R.L.[2], and PANGLE, K.L.[1], [1]Central Michigan University, 1200 S Franklin St, Mt Pleasant, MI, 48859, USA; [2]US Geological Survey Great Lakes Science Center, 1451 Green Rd, Ann Arbor, MI, 48105, USA. **Diet and Growth of Larval Fishes in the St. Clair-Detroit River System.**

The St. Clair-Detroit River System (SCDRS) has a history of environmental degradation and in recent years restoration has been a primary international objective. Larval fish are sensitive to environmental degradation, and individual species respond to habitat changes differently. Analyses of larval fish diets and growth rates across a multitude of species in the SCDRS may provide necessary insight into the evolvement of restoration efforts. The objective of this study was to assess the growth and diet of larval lake whitefish

(*Coregonus clupeaformis*), yellow perch (*Perca flavescens*), and rainbow smelt (*Osmerus mordax*) from the SCDRS on multiple spatio-temporal scales (2010-2015). Growth rates were determined by relating total length to age as measured through otolith analysis. Larval fish gut contents were identified, enumerated, and measured to quantify diet composition. Univariate and multivariate (NMDS, MRPP, CA) analyses were used to analyze diet composition. Our analysis of larval fish diets, and determination of spatial and temporal variability within larval fish communities, provide information on the trophic ecology of this system. Understanding larval fish use of the SCDRS will aid in providing recommendations for implementing science-based adaptive management plans for future restoration projects. *Keywords: Fish diets, Detroit River, St. Clair River, Growth Rates, Lake Erie.*

CRAIG, J.[1], BOASE, J.C.[2], CHIOTTI, J.A.[2], DEBRUYNE, R.[3], DROUIN, R.[4], FRANCIS, J.[5], KENNEDY, G.[1], KNIGHT, R.L.[6], READ, J.[7], ROSEMAN, E.[1], SELZER, M.D.[8], VACCARO, L.[7], and WILLS, T.C.[9], [1]U.S. Geological Survey, Ann Arbor, MI, USA; [2]U.S. Fish & Wildlife Service, Waterford, MI, USA; [3]University of Toledo, Toledo, OH, USA; [4]Ontario Ministry of Natural Resouces and Forestry, London, ON, CANADA; [5]Michigan Department of Natural Resources, Waterford Fisheries Station, Waterford, MI, USA; [6]Great Lakes Fishery Commission, Ann Arbor, MI, USA; [7]University of Michigan Water Center, Ann Arbor, MI, USA; [8]Michigan Office of the Great Lakes, Lansing, MI, USA; [9]Michigan Department of Natural Resources, Lake St. Clair Fisheries Research Station, Harrison Township, MI, USA. **Fishery Management Considerations in an Adaptive Framework for the SCDRS Initiative.**

The international St. Clair-Detroit River System (SCDRS) has a long history of environmental perturbations with numerous restoration programs completed or ongoing to repair damaged habitats and resurrect fish and wildlife populations. The St. Clair-Detroit Rivers System Initiative (SCDRSI) is an interdisciplinary initiative that has evolved to serve as a governance structure guiding decision-making and communication through a network of collaborating scientists and stakeholders. The conceptual framework recognizes ecological and human processes that interact with habitat features to create dynamic environmental conditions that are expressed as variation in abiotic and biotic responses over time. Working toward a common agenda, the SCDRSI identifies and undertakes feasible actions to improve fisheries. Cooperation and collaboration between partners within the SCDRS Initiative serves to reduce duplication and increases monitoring and restoration efficiency on this large Great Lakes connecting channel. *Keywords: Detroit River, Habitat restoration, St. Clair River, Fish management.*

CROFTS, E.J.[1], MEYER, D.N.[2], and BAKER, T.R.[3], [1]Institute of Environmental Health Sciences; Wayne State University, Detroit, MI, USA; [2]Department of Pharmacology, School of Medicine, WSU, Detroit, MI, USA; [3]Institute of Environmental Health Sciences; Department of Pharmacology, WSU, Detroit, MI, USA. **Summary of projects and resources at the Wayne State University GLWA pilot plant field station.**

The Great Lakes Water Authority (GLWA) Water Works Park houses a unique Wayne State University field station which contains a pilot plant and research laboratory. The pilot plant is a scaled-down model of the water plant and enables research on all facets of water treatment processes, including efficiency of contaminant removal. The field station provides access to water collected directly from the Detroit River and any potential contaminants of emerging concern present (e.g., pharmaceuticals and endocrine disrupting chemicals). The field station is equipped with stereo-microscopy with imaging capabilities and multi-sample solid phase extraction equipment. Stereo-microscopy is used to ascertain deleterious effects of contaminants on embryonic development of zebrafish along with other model organisms. Small, mobile zebrafish systems have been set up, acclimated, and utilized in assessing contaminants. Zebrafish and Daphnia models are studied to aid development of biological approaches used to evaluate water quality, focusing on detection of estrogenic and anti-androgenic activity. Additional projects target the efficiency of drinking water treatment processes and various methods of treatment optimization. These projects evaluate urban water infrastructure and identify chemical contaminants with potential adverse health effects.
Keywords: Detroit River, Drinking water, Environmental contaminants.

CROSS, J.S., Alliance for the Great Lakes, 150 Michigan Ave., Ste. 700, Chicago, IL, 60601, USA. **Citizen Scientist, Marine Debris and the Great Lakes.**

Since 1991, the Alliance for the Great Lakes has engaged citizen scientists at Great Lakes beaches in the Adopt-a-Beach™ program. In this program volunteers remove marine debris from Great Lakes shorelines and track catalog their findings. This data is accessible to the public through an online database and can be downloaded by the public. In 2016, over 15,000 volunteers on all 5 Great Lakes and in all 8 Great Lakes states collected and entered 1,132 marine debris data sets for 342 different coastal sites.This presentation will examine results from 2016 and historic datasets on composition and categories of marine debris from a regional, state and local perspective. It will also examine trends in data collected including the variation of smaller fragmented pieces of debris, comprised almost entirely from plastic. Finally, the presentation will discuss a collaborative project with Loyola University from 2016 which analyzed litter intervention strategies to reduce the amount of litter found at Oak Street Beach in Chicago. These strategies included novel trash receptacles, beach visitor education, and visual displays of litter abundance. Citizen scientists play a critical role in not

only litter reduction but also through data collection that can contribute to a better understanding of sources of plastics in the Lakes. *Keywords: Great Lakes basin, Marine debris, Cleanup, Citizen science, Data acquisition.*

CULMAN, S.W. and DAYTON, E.A., The Ohio State University, 2021 Coffey Rd, Columbus, OH, 43210, USA. **Trends in Ohio Agricultural Soil Phosphorus Levels.**

Good news for those concerned about protecting both water quality and agricultural production. Findings presented show that soil test phosphorus levels (STP, Mehlich3-P) are holding steady or trending down in at least 80% of Ohio's 88 counties from 1993 through 2015. The reduction is important because P concentrations in agricultural runoff water are strongly related to STP. More than 2 million STP data points, were provided through the cooperation of the three biggest soil testing laboratories servicing Ohio agriculture (A&L Great Lakes Laboratories, Brookside Laboratories Inc. and Spectrum Analytic). Phosphorus soil testing is the main tool farmers use to determine if phosphorus fertilizer is needed for crop growth and if so how much. In Ohio, crop specific phosphorus fertilizer recommendations come from the Tri-State Fertility Guidelines. Farmers are being asked to avoid applying fertilizer beyond the recommendations in an effort to reduce P runoff. While there is still lots of room for improvement at the higher levels, the fact that so many counties show soil P levels trending down indicates Ohio is moving in the right direction.
Keywords: Management, Monitoring, Nutrients.

CURRIE, W.J.S., BOWEN, K.L., BAILEY, S.A., and KOOPS, M.A., Great Lakes Laboratory for Fisheries and Aquatic Sciences, 867 Lakeshore Rd, Burlington, ON, L7S 1A1, CANADA. **Spatial discrimination of Toronto region zooplankton distributions using a towed sensor array.**

Plankton studies around Canada's largest urban center are rare in spite of the proximity to research resources and designation as an Area of Concern. Plankton surveys of the Toronto Region were undertaken by Fisheries and Oceans Canada (DFO) during September 2013 and monthly in 2016 using station sampling and towed-instruments. The Toronto coast regularly experiences strong, widespread upwellings of cold hypolimnetic water, but also has river inputs, urban runoff and sewage outfalls which can influence plankton distributions. An Acrobat towed-array, with sensors for chl-a, phycocyanin, turbidity, fDOM, temperature, pH, conductivity and oxygen, permitted water masses to be discriminated using multivariate clustering. The Acrobat also had a High-Res Laser Optical Plankton Counter to count and size particles down to ~80-100 µm. Tows were compared with stations spatially grouped to analyse zooplankton community composition from net samples. Inner Toronto Harbour had distinctive water characteristics, but in spite of the warmer, more eutrophic waters, which should promote zooplankton growth, there were low counts, especially of large-bodied zooplankton grazers such as *Daphnia* and a higher percentage of rotifer biomass compared to other sites in Lake Ontario, suggesting poor conditions for population growth around Toronto. *Keywords: Spatial analysis, Zooplankton, Coastal processes.*

CURRIE, W.S.[1], ELGERSMA, K.J.[2], MARTINA, J.P.[3], and BORGEAU-CHAVEZ, L.[4], [1]University of Michigan School of Natural Resources and Environment, Ann Arbor, MI, USA; [2]University of Northern Iowa Biology Department, Cedar Falls, IA, USA; [3]Texas A&M University Department of Ecosystem Science and Management, College Station, TX, USA; [4]Michigan Tech Research Institute, Ann Arbor, MI, USA. **The Mondrian Model: a Tool to Develop an Adaptive Management Framework to Restore Invaded Wetlands.**

Mondrian is an ecosystem model being used as a tool to develop a site-specific adaptive management strategy with the Saginaw Bay CISMA. Mondrian is a highly parameterized model spanning the major levels of ecological organization (individual to ecosystem) that uses hydrology, nitrogen loading, and propagule pressure to simulate local community-ecosystem processes in coastal wetlands. Research with this model has increased our understanding of ecological processes that determine invasion success of non-native *Phragmites australis*. Wetland N cycling combined with N inflows create a threshold in invasion success around a loading of 5 to 15 g N / m^2 y, with the threshold higher in areas with seasonally anaerobic muck. Applied research and model simulations have shown that fall burning and herbicide application can effectively scale back invader success, but long term success is much reduced if N loading remains higher than 10 g N / m^2 y. Additionally, overly aggressive combinations of burning, mowing, and herbicide can promote invasion where N loading is relatively low. A user friendly version of the model is being developed as well as a look up table to aid managers in decision making for treatment and control strategies using site specific conditions. *Keywords: Invasive species, Adaptive management, Model studies, Nutrients.*

CUTRELL, G., VERHAMME, E.M., and DALEY, J.M., LimnoTech, 501 Avis Drive, Ann Arbor, MI, 48108, USA. **Enhancing Monitoring Capabilities with Technology Integration.**

Throughout 2016 extensive monitoring of Lake Erie's physical, biological, and chemical properties were assessed offshore Cleveland, OH. The work was conducted to monitor Lake Erie's water quality for drinking water and environmental monitoring for potential offshore wind development. Three buoys were deployed at four, nine, and fifteen miles offshore Cleveland to measure and report near real-time atmospheric conditions, surface and bottom water quality, and physical lake surface conditions. During 2016 the buoys measured periods of different dissolved oxygen trends between offshore and nearshore Cleveland as well as anoxic water near the Cleveland's water intake. A BioSonics DT-X echosounder was used monthly for fish assessment with subsequent larval and juvenile trawls. Almost no juvenile fish within the hypoxic zone were captured and a large decrease in fish biomass was found offshore Cleveland once lake bottom water became anoxic. To help understand fish behaviors underwater hydrophones were installed to monitor possible fish deterrent sounds. Twenty-six acoustic receivers were also deployed in late-2016 from the shore to fifteen miles offshore to track tagged fish movement. The fish tags detected from the receivers will be submitted into the Great Lakes Acoustics Telemetry Observation System. *Keywords: Lake Erie, Monitoring, Assessments.*

CZAJKOWSKI, K.P.[1], STEPIEN, C.A.[2], MITCHELL, J.[1], SOLOCHA, A.[1], PHILLIPS, J.[1], and SCHEPPLER, H.[1], [1]University of Toledo, 2801 W. Bancroft St., Toledo, OH, 43606, USA; [2]NOAA Pacific Marine Environmental Laboratory, 7600 Sand Point Way, NE, Seattle, WA, 98115, USA. **Geographic Investigation of Potential Invasive Species Introduction Through Bait Stores and Anglers.**

One potential way that invasive species are introduced into the Great Lakes is through anglers dumping their unused bait. The University of Toledo is conducting a study to evaluate the potential hazard of unused bait dumping as a source of invasive species into Lake Erie and its tributaries. Live fish bait samples were collected and analyzed for species from bait stores in the Western Lake Erie watershed. DNA analysis of the fish and tank water will be conducted to determine if invasive species were mixed in with target species. Anglers were surveyed to determine their fishing behaviors. Specifically, anglers were asked where they purchased bait fish and whether they dump unused bait into waterways as well as how often and where they are dumped. Bait shop employees were surveyed to develop a supply chain map of where most bait fish are purchased wholesale. A geographic information system (GIS) was used to map and analyze the data and gather results.
Keywords: Lake Erie, Invasive species, Fish.

CZESNY, S.J.[1], HAPPEL, A.[1], RINCHARD, J.[2], BRONTE, C.R.[3], and KORNIS, M.S.[3], [1]Lake Michigan Biological Station, Illinois Natural History Survey,University of Illinois, 1816 S. Oak street., Champaign, IL, 61820, USA; [2]The College at Brockport, 350 New Campus Drive, Brockport, NY, 14420, USA; [3]U.S. Fish and Wildlife Service, 2661 Scott Tower Drive, New Franken, WI, 54229, USA. **Diet Compositions of Five Salmonid Species in Lake Michigan from 2015.**

The food web of Lake Michigan has been altered by many invasive species which has created gaps in our knowledge of how energy flows through the system. Current predator prey ratios and trawl catches indicate a sparse prey base compared to predator populations. In an effort to better understand how top predators utilize prey resources, stomachs were processed from angler caught salmonids throughout the 2015 fishing year. In brief, we noted many terrestrial invertebrates in stomachs of steelhead trout and Coho salmon, a specialization on alewife by Chinook salmon, and mixed round goby and alewife consumption by lake and brown trout. We also evaluate spatial and temporal differences in diet compositions of the five salmonid species. This data provides more current descriptions of diets of angler caught fishes in Lake Michigan and offers insights in to how top predators fit into this restructured food web. *Keywords: Salmon, Diets, Assessments.*

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DALEY, J.M.[1], BRADLEY, D.L.[1], HANNER, R.H.[2], NAAUM, A.M.[2], DIXON, D.[3], and BLACK, J.[3], [1]LimnoTech, 501 Avis Drive, Ann Arbor, MI, 48108, USA; [2]University of Guelph, Center for Biodiversity Genomics, 50 Stone Road East, Guelph, Ontario, ON, N1G2W1, CANADA; [3]EPRI, 3420 Hillview Avenue, Palo Alto, CA, 94304, USA. **Developing DNA Science and its Potential Impact on Management and Compliance.**

Advances in genetic technologies are exerting broad impacts on diverse fields of research, however, despite the common use in research applications, their use in routine environmental monitoring and management is not well studied. As the cost of sequencing declines and DNA sequence data accumulates, new applications of these tools are emerging that can be used for management decisions and compliance biomonitoring. A case study is presented that demonstrates the feasibility of using these developing tools in an applied biomonitoring community. Great Lakes species of interest (n=7) were selected to evaluate the utility of two genetic methods for early life stage identification of fishes, to determine the effectiveness and state-of-science in compliance applications. The study tested the ability of DNA barcoding to efficiently identify specimens to species, developed and tested novel PCR assays as tools to provide reliable detection of species in complex mixtures and tested the potential to quantify target species biomass using qPCR assays. The results of this study supported the valuable role that genetic methods can play in compliance monitoring but highlighted a need for additional research on understanding boundary conditions that govern the interpretation and use of these methods for compliance and management applications. *Keywords: Monitoring, Genetics, Fish.*

DALTON, B.M. and WOLIN, J.A., Cleveland State University, 2121 Euclid Ave., Cleveland, OH, 44115, USA. **Development of a Rapid Visual Assessment Method for Stormwater Management Features.**

Stormwater management features such as bioretention systems, rain gardens and other green infrastructure provide valuable ecosystem services. These features are used increasingly to mitigate stormwater runoff, and the impacts of aging gray infrastructure. However, once installed few data exist on long-term condition and maintenance. A rapid visual assessment method for stormwater management features was developed utilizing physical characteristics, plant species presence, surrounding land use, and maintenance concerns as a proxy for overall condition. Site visits were conducted between June and August 2015 for 164 bioretention, bioswales, and rain gardens in Greater Cleveland to test this protocol. Five percent of sites were in excellent condition, 34% very good, 35% good, 25% fair, and 1% were poor as determined by four maintenance variables. A multivariate analysis comparing plant species data to environmental variables associates the presence of invasive plant species with a bare dirt substrate and surrounding buildings. Preliminary results suggest a bare dirt substrate is correlated with fair or poor condition, and lower plant diversity. To ensure long-term performance and provide lifetime ecosystem services there is a need for a conclusive maintenance plan and guidelines for proper follow-up and care post-installation. *Keywords: Urban watersheds, Assessments.*

DALTON, D.[1], MAURER, N.[1], NEMER, K.[1], OLSAVSKY, M.J.[1], MINESKY, J.J.[1], COULTER, M.[2], CARNICOM, C.[2], PARKER, R.[2], HODEL, J.[3], and BRONSON, P.[3], [1]Lourdes University, 6832 Convent Boulevard, Sylvania, OH, 43560, USA; [2]The Olander Park System, 6930 Sylvania Avenue, Sylvania, OH, 43560, USA; [3]Metroparks of the Toledo Area, 5100 W. Central Avenue, Toledo, OH, 43615, USA. **Undergraduate Students Using Collaborative Restoration to Establish an Urban Prairie and Oak Savanna.**

Alteration and destruction of terrestrial and aquatic habitats and ecosystems are major concerns in the Great Lakes Region. Under 3% of original savanna, prairie, and sand barrens systems of the Oak Openings Region remain in this once extensive and diverse area of the lake plains and former lake ridges of Lake Erie in NW Ohio and SE Michigan. A highly collaborative restoration project, designed by Lourdes University undergraduates, engaged The Olander Park System (TOPS) and Metroparks of the Toledo Area to establish a prairie and an oak savanna on the urban campus. Students designed the prairie and savanna project via research in two ecological restoration courses and their senior capstones. Service learning experiences embedded in courses enabled students to work with TOPS and Metroparks staff to learn about propagating native plants from seeds and planting native communities. Planting and seeding of about 0.7 acres of tallgrass prairie has occurred on

campus. This student-led, collaborative project will educate students, faculty, staff, and the public about native habitats and ecosystems in the Lake Erie region and conduct seed exchanges with community partners. The project also supports goals of the regional, inter-organizational Green Ribbon Initiative to protect and to restore Oak Openings ecosystems in the region. *Keywords: Habitats, Collaborative restoration, Urban areas, Oak Openings.*

DANESHVAR, F.[1], NEJADHASHEMI, A.P.[1], ZHANG, Z.[2], HERMAN, M.R.[1], SHORTRIDGE, A.[3], and MARQUART-PYATT, S.[4], [1]Department of Biosystems and Agricultural Engineering, Michigan State University, East Lansing, USA; [2]Physical Sciences Division, Department of Statistics, University of Chicago, Chicago, USA; [3]Department of Geography, Michigan State University, East Lansing, USA; [4]Department of Sociology, Michigan State University, East Lansing, USA. **Assessing Impact of Spatial Resolution on Stream Health Based Environmental Justice Models.**

Based on the concept of environmental justice all citizens should be treated fairly with respect to environmental laws while having equal access to information and protection from health hazards. Stream health based environmental justice models are proposed to evaluate equal access to healthy water; however, no proper spatial resolution has been identified for these models. The goal of this study is to find the role of spatial level selection on stream health based environmental justice model performance. In addition, we plan to identify the most proper spatial resolution for representing spatial dependencies among data. The Saginaw River Basin in Michigan was selected as the study area. Seventeen socioeconomic/physiographic indicators representing population, race, gender, income, housing, and education were collected at three spatial levels of county, census tract and block group. These data along with four stream health measures representing fish and macroinvertebrates communities were used for evaluation of the stream health based environmental justice models. Results showed that spatial dependencies are most pronounced at block group level and could better represent spatial variations of stream health measures with respect to socioeconomic/physiographic indicators. *Keywords: Spatial analysis, Stream health, Human health, Environmental Justice, Modeling.*

DANIEL, S.E.[1], BURLAKOVA, L.E.[1], KARATAYEV, A.Y.[1], MEYER, K.[2], and HINCHEY, E.K.[3], [1]Great Lakes Center, 1300 Elmwood Avenue, Buffalo, NY, 14216, USA; [2]ORISE Fellow, U.S. EPA Great Lakes National Program Office, 77 W. Jackson Blvd., Chicago, IL, USA; [3]U.S. EPA Great Lakes National Program Office, 77 W. Jackson Blvd., Chicago, IL, USA. **The effect of *Dreissena* on sediment organic matter and Oligochaeta in the Great Lakes.**

The impacts of zebra mussels (*Dreissena polymorpha*) on lake benthic communities are very well known, however we have less information on the impacts of quagga mussels (*D. rostriformis bugensis*) on profundal benthic ecosystems. In this study we explore the impacts of quagga mussels on Oligochaeta in profundal zones of the Great Lakes. It has been hypothesized that *Dreissena* filtering activities increase the deposition of organic material promoting some species of Oligochaeta. To test this hypothesis we used data obtained from the U.S. EPA Great Lakes National Program Office's Biology Monitoring Program (2003-2015), and intensive studies of Lake Erie (2014) and Lake Michigan (2015) as part of the Cooperative Science and Monitoring Initiative. We also collected sediment cores in 2014 and 2016 to study vertical distribution of Oligochaeta and organic material. We found that mean Oligochaeta mass was significantly higher in samples with greater mussel density and higher densities of dreissenids increased the abundance of Oligochaeta in oligotrophic lakes. We also found significant changes in organic matter depending on *Dreissena* density and biomass. We will discuss potential mechanisms of *Dreissena* effects on Oligochaeta in the profundal zone of the Great Lakes. *Keywords: Benthos, Organic carbon, Dreissena.*

DARNTON, R.W.[1], KOWALK, K.A.[1], ELLISON, R.[2], and CORUM, S.[1], [1]EA Science and Technology, 5918 Meridian Blvd, Suite 4, Brighton, MI, 48116, USA; [2]U.S. Environmental Protection Agency, 9311 Groh Road, Grosse Ile, MI, 48138, USA. **Assessment of Contaminated Sediments in the Detroit River and Comparison with Historical Use Data.**

An assessment of contaminated sediments was performed on the American side of the Detroit River Area of Concern between 2012 and 2016. This assessment was conducted in five segments: Harbortown Area, Riverbend Area, River Rouge/Ecorse Shoreline, Mid/Lower Trenton Channel, and the Celeron Island Area. Contaminants of concern varied between segments but typically included polychlorinated biphenyls, polycyclic aromatic hydrocarbons, and heavy metals. Statistical analyses of the combined data from these assessments and comparisons with consensus based sediment quality guidelines (*MacDonald et al. 2000*) were used to identify locations with the highest proportions of contaminants of concern. This data was compared with known historical uses and discharges along the Detroit River shoreline and surrounding watershed to further gauge impacts and target areas for additional evaluation. The analysis also included consideration of how prevailing flow regimes could potentially have transported contamination from in-place historical activities to locations of contaminant deposits identified by these sediment assessments.
Keywords: Sediment quality, Historical use, Environmental contaminants, Detroit River.

DARRAH, C., Great Lakes Water Protection Committee, 492 Peterboro St., Detroit, MI, 48201, USA. **The Lack of Communication Between Great Lakes Water Protection Committee and Great Lakes Water Auth.**

On January 1, 2016 Great Lakes Water Authority, formedv inn Detroit bankruptcy proceedings, took over water and wastewater treatment from Detroit Water and Sewerage Department, serving 3.5 million people. In the fall of 2015 citizens formed Great Lakes Water Protection Committee to advise incoming GLWA. GLWPC wrote many letters and gave oral presentations to GLWA regarding the need to change from elemental chlorine disinfection to safer disinfection process, the need to eliminate polyacrylamides from dewatering and move to calcium oxide, the need to have chemists doing analyses, etc. GLWA did not respond to any raised questions and remained incommunicado. This is why in spring of 2016 GLWPC presented a paper at IAGLR annual conference at Guelph, Canada, entitled " A Tale of Two Cities " comparing the mum Detroit to open Boston.
Keywords: Pollutants, Environmental policy, Detroit River.

DART, A.[1], ROBB, A.[1], VANDERPLOEG, H.A.[2], and CARRICK, H.[1], [1]Dept. Biology & Institute for Great Lakes Research, Central Michigan University, Mt. Pleasant, MI, 48859, USA; [2]Great Lakes Environmental Research Laboratory, National Oceanic & Atmspheric Adminiatration, Ann Arbor, MI, 48108, USA. **Picoplankton dominant the particulate P pool along a near to offshore gradient in Lake Michigan.**

Nutrients such as phosphorus (P) play an important role within fresh water lakes, and can influence the level of productivity through bottom up influences. Following reduced watershed loadings, P concentrations have declined in southern Lake Michigan over the past 30 years; this reduction has coincided with a change in the species composition of the phytoplankton assemblage there. Moreover, the establishment of invasive mussels (Dreissena) over past decade in Lake Michigan, may have further altered the P content of the lake. As such, this study examined the concentration and size structure of particulate phosphorus (PP) and P storage as poly-phosphates (poly-P) in the plankton assemblage in southern Lake Michigan along a near to offshore gradient (from 2014-2016). In all years, the majority of PP and poly-P was contributed by pico-sized particles (>80% of total among all samples). Both PP and poly-P varied significantly along a near to offshore gradient in Lake Michigan, where the greatest values measured nearshore. Poly-P concentrations were greatest during mixing and early stratification periods, and these levels gradually decreased throughout the year. These results suggest that pico-sized particles were the largest sink of P in the pelagic zone, and that the stored P pool declined during the stratification period.
Keywords: Lake Michigan, Picoplankton, Phosphorus, Plankton.

DASILVA, A. and KOWALSKI, K., U.S. Geological Survey, 1451 Green Rd, Ann Arbor, MI, 48105, USA. **Developing the Monitoring Protocol for the *Phragmites* Adaptive Management Framework (PAMF).**

The *Phragmites* Adaptive Management Framework (PAMF) is a new management strategy for non-native *Phragmites australis* in the Great Lakes basin (http://greatlakesphragmites.net/pamf/). This framework provides participating land managers with access to a database of information derived from each enrolled *Phragmites* patch, annual treatment guidance generated by predictive models, and a standardized monitoring protocol that guides collection of key response data. Although there are many ways that *Phragmites* and other plant species can be monitored, it is critically important to adopt an approach that targets variables needed to inform learning, yet is simple and easy enough for all user groups to adopt. The PAMF team developed a scalable, easy-to-use monitoring protocol that serves the PAMF objectives and provides a common foundation for other regional monitoring and assessment efforts. *Keywords: Decision making, Adaptive management, Monitoring, Invasive species.*

DAVID, S.R., USGS/Shedd Aquarium, 1451 Green Road, Ann Arbor, MI, 48105, USA. **Adapting Great Lakes science to social media: garish examples from the field.**

Adapting science to changing conditions of the Great Lakes is a reality and necessity. We must adapt how we communicate that science to the public, policymakers, and fellow scientists. Social media can be an effective tool of science communication. Incorporating social media into science communication can be viewed like adding collaborators to a research project. Social media examples will be shared to show that when used appropriately, they are valuable tools in modern day fisheries and conservation science, and can help make Great Lakes science more accessible. *Keywords: Education, Conservation, #scicomm, Communication, Outreach.*

DAVID, S.R., USGS/Shedd Aquarium, 1451 Green Road, Ann Arbor, MI, 48105, USA. **Regarding Jim Diana: Over a decade of fish research from the Great Lakes to Mexico.**

His influence on fisheries science and ecology spans the Great Lakes region, and literally, across the world. I've had the privilege of having Jim Diana as an advisor, mentor, supervisor, and friend; further, we've worked on diverse projects ranging from fish communities in the Muskegon River, to conservation of Great Lakes peripheral populations, to sustainable aquaculture of Central American air-breathing fishes. In this presentation I will summarize my research with Jim that has spanned over 10 years; integral anecdotes will be included along the way (e.g. gar versus pike, and who really caught the biggest fish at

orientation). Through teaching, research, and mentorship, Jim and Barb Diana truly created a sense of family in the aquatics department at the University of Michigan, and their positive impact will be felt through many recruitment classes to come. *Keywords: Biodiversity, Teaching, Fish, Outreach, Fish populations, Education.*

DAVIS, J.J. and NEELEY, R.N., U.S. Fish and Wildlife Service Carterville FWCO, Wilmington Substation, 30929 Rt. 53, Wilmington, IL, 60481, USA. **Effects of barge vessel transit on the efficacy of the CSSC Electric Dispersal Barrier.**

The most substantial pathway for the movement of invasive fishes between the Mississippi River Basin and the Great Lakes Basin is the Upper Illinois Waterway. An Electric Dispersal Barrier System (EDBS) was constructed here to prevent inter-basin fish movement while maintaining the continuity of this important shipping route. In 2016, the U.S. Fish and Wildlife Service, U.S. Geological Survey, and U.S. Army Corps of Engineers undertook a large-scale field study to determine the influence of commercial barge vessels on the efficacy of the EDBS in preventing fish passage. This study included sonar-based observations of wild fish as a tow consisting of a tug vessel and six fully-loaded barges traversed the EDBS. Additionally, as the tow passed through the EDBS, its effect on flow velocities and voltage gradients were measured. Schools of juvenile fish moved upstream and completely crossed the peak electrical field of the EDBS concurrent with the passage of downstream transiting tows in 89.5% (n = 19) of trials. Based on these results, the efficacy of the EDBS in preventing upstream passage of small fish is compromised while tows are moving across the barrier system. This observation of upstream fish passage identifies a potential pathway for the movement of invasive fishes through the EDBS and into the Great Lakes. *Keywords: Acoustics, Biological invasions, Carp.*

DAVIS, L.A., NEUENHOFF, R.D., WITHERS, J.L., and SWEKA, J.A., U.S. Fish and Wildlife Service, Northeast Fishery Center, Lamar, PA, 16848, USA. **Tracking a Big Fish in a Big Lake: Assessing Lake Sturgeon Movement in Eastern Lake Erie.**

An understanding of the spatial ecology of fish species is an important aspect in managing populations that are data deficient. Advances in technology and collaborative telemetry provide the opportunity to conduct studies over large spatial and temporal scales. We used acoustic telemetry as a partner in a collaborative, multi-agency network (Great Lakes Acoustic Telemetry Observation System - GLATOS) to evaluate the movements of 54 Lake Sturgeon (Acipenser fulvescens) throughout eastern Lake Erie and portions of the upper Niagara River. Data provided important information into movements not only in the far-eastern portion of Lake Erie but also farther west towards the central basin. Movements appeared to vary among individuals and seasons. Some individuals demonstrated high site fidelity while others displayed long-range movements (e.g., greater than 90 km) at certain times of the year. Information collected provided important insight into the potential geographic range of Lake Sturgeon in Lake Erie that is needed to set recovery targets for this ancient, keystone species. Our study also highlights the advantages to using and contributing data to a collaborative, multi-agency acoustic telemetry network. *Keywords: Acoustics, Lake Erie, Migrations.*

DAVIS, T.W.[1], ROWE, M.D.[2], ANDERSON, E.J.[1], VANDERWOUDE, A.[3], JOHENGEN, T.H.[2], RUBERG, S.[1], STUMPF, R.P.[4], and DOUCETTE, G.[5], [1]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, USA; [2]Cooperative Institute for Limnology and Ecosystems Research, University of Michiga, Ann Arbor, MI, USA; [3]Global Science and Technologies, Greenbelt, MD, USA; [4]NOAA National Centers for Coastal Ocean Science, Silver Spring, MD, USA; [5]NOAA National Centers for Coastal Ocean Science, Charleston, SC, USA. **Combining advanced technologies to develop an early warning system for HABs in western Lake Erie.**

Harmful algal blooms (HABs) can negatively impact ecosystem and human health. We have developed components of an early warning system that allows water managers to respond to predicted changes in water quality. NOAA products, such as the Lake Erie Experimental HAB Bulletin and the Lake Erie Experimental HAB Tracker, provide information on bloom location, biomass and predicted movement. Furthermore, advanced technologies, such as hyperspectral imaging and the Environmental Sample Processor (ESP), are being used to provide additional data and help bridge some gaps in the current HAB forecasting products. We present a case study combining these tools to serve as an early warning system. On 19 Sept 2016 hyperspectral flyovers detected a near-shore scum close to Monroe, Michigan that was not detected using satellite imagery. Archived HAB Tracker runs were reviewed to determine the transport pattern that contributed to the development of the scum. HAB Tracker nowcast and forecast runs provided information on the predicted horizontal and vertical movement of the bloom biomass. This information was provided to the Monroe water mangers, who reported water quality issues in their intake water samples on 17-19 Sept. In the future, the ESP will provide near real-time particulate microcystins data for improved evaluation of toxicity risks. *Keywords: Harmful algal blooms, Lake Erie, Remote sensing.*

DAYTON, E.A. and WHITACRE, S.D., The Ohio State University, 2021 Coffey Rd, Columbus, OH, 43210, USA. **On-Field Ohio! Findings for Important Causes and Controls of Ohio Agricultural Phosphorus Runoff.**

Is there any hope for reducing agricultural phosphorus (P) runoff? Does farmer management matter? Is it possible to protect surface water quality and maintain Ohio agricultural production? Using Ohio surface and tile edge-of-field P runoff monitoring data and crop management simulations, runoff P concentration and load across a broad range of crop management scenarios, topographies, and soil P levels will be presented. Also presented are relative contributions from surface and tile to Ohio runoff P. Opportunities for substantial P runoff reductions will be discussed. This work is part of the On-Field Ohio! project to evaluate/revise the Ohio P Risk Index and the College of Food, Agricultural, and Environmental Sciences at the Ohio State University's Field to Faucet initiative. The Ohio P Index is part of a USDA-NRCS nutrient management plan and is intended to provide a field-scale estimate of runoff P risk based on field characteristics and farmer management. It is increasingly being used to judge Ohio farmer performance, so it is important to "get it right." The ability to quantify reductions in P runoff will allow farmers to prioritize time and resources to make effective management decisions. *Keywords: Phosphorus, Management, Water quality.*

DEBRUYNE, R.L.[1], ROSEMAN, E.F.[1], and ROSS, J.E.[2], [1]USGS Great Lakes Science Center, Ann Arbor, USA; [2]USFWS Ashland Fish and Wildlife Conservation Office, Ashland, USA. **Snapshot in Time: Identifying Restoration Needs and Challenges in St. Clair-Detroit River System.**

Development of habitat restoration targets and post-restoration monitoring strategies can be focused using a viability analysis framework that supports an adaptive management process. In the St. Clair-Detroit River System (SCDRS), we used a viability analysis framework to evaluate environmental parameters associated with fisheries and aquatic restoration efforts and to gauge the overall health of the aquatic environment. Steps to derive the viability analysis included: establishing meaningful baseline metrics, identifying information deficiencies, and placing the context of current conditions into a usable format for managers and practitioners. Many metrics were unable to be assessed or assigned condition status, which identified data gaps in monitoring. Metrics associated with native migratory fishes, Lake St. Clair, and islands are generally in better condition than metrics associated with the coastal terrestrial system, aerial migrants, and coastal wetlands. This was not unexpected given the highly urbanized landscape of the SCDRS. Viability analysis is a robust and accommodating framework, adaptable to any restoration monitoring program and, through the determination of common desired endpoints, can aid consensus building and collaboration across jurisdictional boundaries. *Keywords: Detroit River, St. Clair River, Indicators.*

DEBUES, M.J. and EIMERS, M.C., Trent University, 1600 West Bank Dr, Peterborough, ON, K9J 0G2, CANADA. **Agricultural land-use change and nutrient export in Lake Ontario tributaries.**

Since the 1970s, there have been significant changes to the agricultural landscape in Ontario, notably a rise in row crops at the expense of pasture land. These changes have occurred over the same time that nitrate levels increased in agriculturally-dominated streams around Lake Ontario, whereas total phosphorus levels were either stable or in decline. These corresponding trends suggest a possible relationship between agricultural land cover change, and stream nutrient levels in tributaries along the Lake Ontario shoreline. To test this hypothesis, water was sampled at 12, second-order streams, in several watersheds of Lake Ontario tributaries including Soper Brook, Wilmot Creek, Graham Creek, and the Ganaraska River. Sites were located downstream from land dominated by either row crops, pasture, or forested/natural cover. Samples were analyzed for total phosphorus and nitrogen, as well as nitrate and dissolved phosphorus. Nitrate levels were by far greatest in row crop sites, while differences in total phosphorus were unclear. A larger fraction of dissolved nutrients was found in row crop sites compared to pasture or natural sites. This research offers insight into the role of non-point landscape contributions to nutrient loading to the Great Lakes, specifically those contributions driven by changes in agricultural practices. *Keywords: Lake Ontario, Nutrients, Tributaries.*

DELVAUX, J.D.[1], LEASK, S.M.[2], LAFRANCOIS, B.M.[2], and BOOTSMA, H.A.[1], [1]University of Wisconsin-Milwaukee School of Freshwater Sciences, 600 E. Greenfield Avenue, Milwaukee, WI, 53204, USA; [2]National Park Service, 2800 Lake Shore Drive Easst, Ashland, WI, 54806, USA. **Tributary Influence on the Biogeochemistry and Metabolism of Nearshore Lake Superior.**

Nearshore areas of the Great Lakes often have relatively high biodiversity, and as the interface between the terrestrial landscape and the open lake they play an important role in modulating whole-lake response to inputs of nutrients and energy from the watershed. These inputs occur primarily via tributary loading, and so it is critical to understand the dynamics of river plumes and the fate of organic carbon and nutrients delivered in the plumes. To assess the influence of river plumes on the biogeochemistry and metabolism of the Lake Superior nearshore zone, the spatial and temporal distribution of turbidity, nutrients, phytoplankton, dissolved oxygen, and dissolved carbon dioxide were measured in the western arm of Lake Superior and select tributaries from June 2016 through October 2016. This presentation will focus on the lake response to a large storm even in July, showing how the nearshore zone transitioned from a highly turbid, low productivity system immediately following the storm to high phytoplankton productivity after a one-month lag.

A decrease in surface pCO_2 during this period suggests that river nutrient loads have a greater effect than organic carbon loads on nearshore community metabolism.
Keywords: Metabolism, Lake Superior, Nutrients.

DENNEY, M.K.[4], FARMER, A.T.[2], KRAUSFELDT, L.E.[1], ZASTEPA, A.[3], BINDING, C.E.[3], WATSON, S.B.[3], CASTRO GONZALEZ, H.F.[2], CAMPAGNA, S.R.[2], and WILHELM, S.W.[1], [1]Department of Microbiology, The University of Tennessee, Knoxville, TN, USA; [2]Department of Chemistry, The University of Tennessee, Knoxville, TN, USA; [3]Environment and Climate Change Canada, Burlington, ON, CANADA; [4]The Graduate School of Genome Science & Technology, Knoxville, TN, 37916, USA. **Characterizing the lipidome of Microcystis blooms in Lake Erie (2015).**

Phosphorus is an obligate nutrient for growth and metabolic function of cyanobacteria. Substitution of non-phosphorus lipids for phospholipids is thought to be a common method for marine cyanobacteria to reduce cellular phosphorus quotas, allowing for continued cell growth and reproduction when phosphorus is limited. Indeed, it has been demonstrated that marine phytoplankton have a predictable alteration of their lipidome to increase sulfolipid content in response to phosphorus-scarcity. Logically, in situations where phosphorus may be limiting such as those in *Microcystis*-driven algal blooms of Lake Erie, a similar response to phosphorus-limited conditions is expected. In laboratory samples, *Microcystis aeruginosa* grown in 164 µM and 3.28 µM phosphorus and analyzed by ultra-performance liquid chromatography with orbitrap mass spectrometer demonstrated an average of 37.5% ($p < 0.001$) increase of the sulfolipid sulfoquinovosyldiacylglycerol (SQDG) during phosphorus-limited growth. This data along with field and mesocosm surveys from the largest *Microcystis* bloom recorded to date in Lake Erie (summer 2015) will be presented to demonstrate how the lipidome may respond to phosphorus availability.
Keywords: Microcystis, Sulfolipid, Lake Erie, SQDG, Mass spectrometry, UPLC.

DENNHARDT, A.J.[1], MAURER, B.A.[1], FETZER, W.W.[2], BENCE, J.R.[2], BRENDEN, T.O.[2], COTTRILL, A.[3], MCLEISH, D.[3], RISENG, C.M.[4], WEHRLY, K.E.[5], and FORSYTH, D.K.[5], [1]Center for Statistical Training and Consulting, Department of Fisheries and Wildlife, MSU, 293 Farm Lane, 178 Giltner, East Lansing, MI, 48824, USA; [2]Quantitative Fisheries Center, Department of Fisheries and Wildlife, MSU, 375 Wilson Road, 101 Urban Planning and Landscape Architecture, East Lansing, MI, 48824, USA; [3]Ministry of Natural Resources and Forestry, Upper Great Lakes Management Unit, 1450 7th Avenue East, Owen Sound, ON, N4K 2Z1, CANADA; [4]School of Natural Resources and Environment, UM, 440 Church Street, Ann Arbor, MI, 48109, USA; [5]Institute for Fisheries Research, Michigan Department of Natural Resources, UM, 1109 North University

Avenue, Ann Arbor, MI, 48109, USA. **Spatiotemporal Factors and their Impacts to Lake Huron Fish Communities.**

Understanding factors associated with species' population variability over time is essential to management of ecologically- and commercially-important fisheries. At odds with such goals is the difficulty of acquiring broad-scale time series data on fish abundance and historic data on multiple environmental factors. More challenging still is the inability to simultaneously assess long-term abundances for multiple species in a single community. Dynamic Factor Analysis is a state-space modeling tool designed for simultaneously evaluating multivariate time series to identify factors that influence ecological populations and communities over time. We acquired long-term data on fish communities, as well as historic data on lake factors to relate to their dynamics, in multiple areas sampled across Lake Huron Canadian waters during 1998 - 2011. Results showed that fish communities responded strongly to annual changes in (1) commercial harvest pressure, (2) nutrient cycling patterns, and (3) Sea lamprey numbers across the lake. We demonstrate that Dynamic Factor Analysis is therefore a useful tool for evaluating fish community dynamics over time, and our findings suggest that management should focus on stabilizing broad-scale harvests, Sea lamprey control, and structural conditions that support nutrient cycling annually in the lake.

Keywords: Fish populations, Fish communities, Modeling, State-space model, Lake Huron, Dynamic Factor Analysis.

DEPEW, D.C.[1], DOVE, A.[1], HOWELL, E.T.[2], and BACKUS, S.[1], [1]Environment and Climate Change Canada, 867 Lakeshore Rd, Burlington, ON, L7S 1A1, CANADA; [2]Ontario Ministry of Environment and Climate Change, 125 Resources Rd., Etobicoke, ON, CANADA. **An assessment of Cladophora biomass variability in the Great Lakes: Implications for monitoring.**

Amendments to the Great Lakes Water Quality Agreement (GLWQA) in 2012 identified the maintenance of algal biomass below levels that constitute a nuisance. For benthic species (e.g. *Cladophora* sp) that frequently meet this nuisance criteria, the lack of a comprehensive monitoring program has been repeatedly cited as a critical factor hindering the assessment of current status, but also of changes over time in response to ecosystem perturbation or management action. Given the renewed focus on *Cladophora* in the Great Lakes, a comprehensive assessment of existing data, monitoring approaches and their ability to detect change is warranted as it will be of critical importance to distinguish changes as a result of further nutrient management from changes imposed by other factors. Existing data for Lakes Erie, Ontario and Huron from 1971 - 2014 were compiled and analyzed using a components of variance approach. Different variance structures were identified for different time periods and different lakes indicating the control of accrued biomass may differ from lake to lake. The results of this analysis will be discussed with an eye toward developing a suitable monitoring strategy. *Keywords: Benthos, Cladophora, Monitoring.*

DERMINIO, D.S. and BOYER, G.L., State University of New York College of Environmental Science and Forestry, 1 Forestry Dr., Syracuse, NY, 13210, USA. **Impacts of Hydrogen Peroxide on the Growth of Cyanobacteria and Chlorophytes.**

Algal blooms are increasing on a worldwide scale. This includes cyanobacteria blooms that produce toxins that impact recreation, human, and ecosystem health. Hydrogen peroxide (H_2O_2) has been proposed as a control method to limit the growth of these cyanobacteria blooms. Here, the sensitivity of different species of cyanobacteria and chlorophytes to H_2O_2 was examined. Cyanobacteria in the genera *Anabaena*, *Microcystis*, and *Woronichinia* and chlorophytes in the genera *Chlorella*, *Chlamydomonas*, and *Scenedesmus* were grown in Z8 using a 12:12 light:dark cycle at 22ºC with the addition of various concentrations of H_2O_2. *In vivo* fluorescence, catalase activity, and toxin production were measured at the beginning and end of each experiment. Different species, even within the same genus, reacted differently to the addition of H_2O_2. This suggests the use of H_2O_2 to control harmful cyanobacterial blooms must carefully consider which genera and species are present. *Keywords: Harmful algal blooms, Hydrogen peroxide, Remediation.*

DESTASIO, B.T., ACY, C.N., FRANKEL, K.E., FRITZ, G.M., and LAWHUN, S.D., Biology Dept., Lawrence University, 711 E. Boldt Way, Appleton, WI, 54911, USA. **How to clean AIS from those waders and nets? Tests of effectiveness of decontamination techniques.**

The spread of aquatic invasive species (AIS) in the Laurentian Great Lakes is a major environmental issue and there is a pressing need for scientific information on which procedures can effectively decontaminate boats, trailers, and sampling gear. We determined effectiveness of cleaning methods on four recent AIS: *Potamopyrgus antipodarum* (New Zealand mud snail-NZMS), *Bythotrephes longimanus* (spiny water flea-SWF), *Hemimysis anomala* (bloody red shrimp-BRS) and *Bithynia tentaculata* (faucet snail-FS). We tested mortality in the lab following total immersion and spraying, as well as the effects of five types of materials likely to be contaminated. Freezing was effective, but usually not practical. Drying did not work on NZMS or FS. Bleach (500 ppm) was effective on SWF and BRS, but not NZMS or FS. Immersion in Virkon (2%) was effective on all species within 20 min. Spraying was less effective than total immersion, especially on some materials. Our results provide rigorous data for establishing practical guidelines on decontamination methods for managers, researchers and citizen scientists battling the spread of AIS in the Great Lakes.
Keywords: Monitoring, Invasive species, Great Lakes basin.

DIANA, J.S.[1], NOHNER, J.K.[2], ZORN, S.Z.[1], RUST, A.[1], BATTIGE, K.[1], and HANCHIN, P.[3], [1]University of Michigan, 440 Church Street, Ann Arbor, MI, 48109-1041, USA; [2]Michigan Department of Natural Resources Fisheries Division, 525 W. Allegan St., Lansing, MI, 48933, USA; [3]Michigan Department of Natural Resources Fisheries Division, 96 Grant Street, Charlevoix, MI, 49720, USA. **Muskellunge Spawning Habitat: Reviewing Twenty Years of Research in the Jim Diana Lab.**

This presentation synthesizes work conducted by Jim Diana and his collaborators on the spawning habitat of Muskellunge in the Great Lakes Basin. Inland lake studies found Muskellunge prefer to spawn over finer sediments near emergent and submerged vegetation in protected bays or shorelines, in addition to other preferred habitat types that will be presented. In lakes or rivers, GIS-based models using Maxent are able to predict Muskellunge spawning habitat based on habitat variables at multiple scales. Habitat selection of Great Lakes and inland strain Muskellunge included some similar factors like shallow depth and low slope, but Great Lakes Muskellunge were also found to prefer moderate vegetative cover and woody debris. We propose a general model of Muskellunge spawning and nursery habitat where survival from egg to larva is limited by water quality and predation during incubation. Water quality in streams is regulated by conditions in the stream and its watershed, while in lakes it is also substantially affected by substrate and shoreline conditions. Egg predation is probably reduced by refuge in vegetation, woody debris, and complex sediments with interstitial space. Food and predation refuge are likely improved by presence of woody debris and vegetation. *Keywords: Habitats, Spawning, Recruitment, Shoreline development, GIS.*

DIANA, M.J., Michigan Department of Natural Resources, 621 N 10th St, Plainwell, MI, 49080, USA. **Stocking success, impacts on fish populations, and spillway escapement of muskellunge in Illinois.**

Muskellunge are broadly distributed across the northern United States and southern Canada and are highly sought after by anglers. Intraspecific genetic variation suggests the existence of divergent stocks related to residence in major river drainages. Dr. James Diana's research has been integral in understanding muskellunge ecology. His influence has been felt both directly and indirectly through the people he has influenced. Although I have never worked with Dr. Diana directly, he has influenced my research direction with muskellunge and I will present this information here. In this study, I examined differences in survival and growth among stocks of Muskellunge stocked into lakes throughout Illinois. In addition, impacts of muskellunge additions and spillway escapement were evaluated. Stocking mortality was related to temperature and was greatest for Illinois and Ohio fish that were stocked during the early fall. Mississippi fish experienced high mortality over the first summer following stocking, resulting in the lowest abundance and smallest size. Few impacts on sportfish species were observed following introductions. Spillway escapement of muskellunge was significant during high flows. These factors can influence future stocking and population management decisions. *Keywords: Fish populations, Muskellunge, Fish management, Fish populations.*

DILA, D.K.[1], CORSI, S.R.[2], LENAKER, P.L.[2], BALDWIN, A.K.[2], BOOTSMA, M.J.[1], and MCLELLAN, S.L.[1], [1]School of Freshwater Sciences, University of Wisconsin-Milwaukee, Milwaukee, WI, 53204, USA; [2]U.S. Geological Survey, Wisconsin Water Science Center, Middleton, WI, 53562, USA. **Host-associated fecal indicators driven by hydrology, precipitation and watershed land use.**

Fecal contamination from stormwater, leaking infrastructure, sewage discharges, agricultural runoff, and wildlife is a pervasive problem in Great Lakes watersheds. Sewage and agricultural contamination is of particular concern as they carry multiple stressors to the environment including nutrients, chemical contaminants, pharmaceuticals and human pathogens. This study used alternative indicators of fecal pollution, which included human and ruminant markers, to assess eight Great Lakes watersheds discharging to Lake Michigan or Lake Erie, with a range of land uses. Flow composited river samples were collected over low-flow periods (n=89) and during rainfall or snowmelt runoff-event periods (n=130). All event samples from urban watersheds had evidence of human fecal pollution, with mean concentrations above 1000 CN/100 ml of human markers in >85% of those samples. Agricultural watersheds also had evidence of human fecal pollution. Additionally, ruminant marker was found in ~60-100% of runoff-event samples in agricultural watersheds. Statistical modeling indicated rain depth, season, percent tile drainage, and human or cattle density explained variability in daily flux of host-associated fecal indicators. Mapping watershed indicator loads can inform policy makers in restoration efforts to reduce these frequent pollution sources. *Keywords: Watersheds, Microbiological studies, Risk assessment.*

DILLON, R.A.[1], CONROY, J.D.[2], RUDSTAM, L.G.[3], and LUDSIN, S.A.[1], [1]Aquatic Ecology Lab, Department of Evolution, Ecology, and Organismal Biology, The Ohio State Univ, 1314 Kinnear Rd, Columbus, OH, 43212, USA; [2]Inland Fisheries Research Unit, Division of Wildlife, Ohio Department of Natural Resources, Hebron, OH, USA; [3]Department of Natural Resources and the Cornell Biological Field Station, Cornell University, Ithaca, NY, USA. **Quantifying Potential Bias of Planktonic Invertebrates in Acoustic Surveys of Prey Fish Density.**

Hydroacoustic surveys are often used to estimate prey-fish distribution, density, and biomass in lakes. These surveys, however, may not exclusively detect the target of interest.

For example, some planktonic macroinvertebrates (e.g., *Chaoborus*) have air bladders that resonate well at frequencies (e.g., 200 kHz) commonly used in prey-fish assessment surveys. In turn, prey-fish density can be overestimated, if this source of error is not removed. Herein, we sought to quantify the potential bias associated with using a 200-kHz transducer to estimate prey fish density, which is currently done in western Lake Erie and other Ohio lakes. We conducted multi-frequency (70- and 200-kHz) hydroacoustic surveys during August 2016 in six shallow lakes analogous to nearshore habitats in the Great Lakes (e.g., western Lake Erie, Green Bay). Our data showed evidence for bias induced by *Chaoborus*, with density being overestimated by 1.4- to 7.1-fold when using a 200-kHz transducer. Ultimately, our study indicates the importance of accounting for vertically migrating invertebrates in lake acoustics surveys, and suggests that 200-kHz transducers should only be used if accompanied by a lower-frequency transducer (e.g., 70- or 120-kHz) when *Chaoborus* are present. *Keywords: Dorosoma cepedianum, Macroinvertebrates, Vertical migration, Hydroacoustics, Prey availability, Fish management.*

DIPPOLD, D.A.[1], ALOYSIUS, N.[2], YEN, H.[3], KEITZER, S.E.[4], ARNOLD, J.[5], ROBERTSON, D.M.[6], WHITE, M.[5], SOWA, S.P.[7], SASSON, A.[8], REWA, C.[9], FRAKER, M.E.[1], and LUDSIN, S.A.[1], [1]The Ohio State University, Department of Evolution, Ecology, and Organismal Biology, Columbus, OH, 43210, USA; [2]The Ohio State University, Department of Agriculture, Columbus, OH, 43210, USA; [3]Blackland Research & Extension Center, Texas A&M University, Temple, TX, 76502, USA; [4]Tusculum College, Department of Natural Sciences, Greeneville, TN, 37743, USA; [5]Agricultural Recourse Center, United States Department of Agriculture, Temple, TX, 76502, USA; [6]Wisconsin Water Science Center, United States Geological Survey, Middleton, WI, 53562, USA; [7]The Nature Conservancy Michigan Field Office, Lansing, MI, 48906, USA; [8]The Nature Conservancy Ohio Field Office, Dublin, OH, 43017, USA; [9]Resource Assessment Division, United States Department of Agriculture, Beltsville, MD, 20705, USA. **Forecasting the Effects of Climate and Land-Use Change on Lake Erie's Fish Populations.**

Climate and land-use change are altering chemico-physical processes in the Lake Erie ecosystem. Changes include shorter winters, faster spring warming rates, and increased precipitation-driven river discharge and spring-time nutrient loading, relative to the past. Although we have some knowledge of how these factors may independently affect the dynamics of economically and ecologically important Lake Erie fishes, like walleye (*Sander vitreus*) and yellow perch (*Perca flavescens*), their combined effects remain speculative. Herein, we used a biophysical modeling approach to forecast how the western-basin populations of these two species might change during 2017-2065 under two greenhouse gas emission scenarios crossed with four agricultural land-use scenarios. Specifically, we used the output from 19 IPCC climate models to inform a, calibrated-validated, spatially-explicit watershed-hydrology model (SWAT). Output from SWAT was then used in predictive models of age-0 (juvenile) walleye and yellow perch abundances, which are strong predictors of future recruitment to the fishery. Beyond providing novel insight into the independent and combined impacts of climate and land use change on percid recruitment, we discuss how our findings can be used to help agencies sustainably manage these vital populations in the future. *Keywords: Eutrophication, Fisheries management, Ecosystem modeling, Percids.*

DOBIESZ, N.E. and CLARK, R., MSU Quantitative Fisheries Center, 375 Wilson Rd., Room 101, East Lansing, MI, 48824, USA. **What we know, don't know, and need to know about round gobies in the Great Lakes.**

In this session we explored the impacted of round gobies on food webs and fish communities across the Great Lakes. Here we summarize the status of round gobies, critical research needed and underway, and the challenges ahead to better manage round goby as both an increasingly important prey fish and as an invader. *Keywords: Fish populations, Round goby, Food chains, Management.*

DOBULIS, M., GREESON, E., KWIATKOWSKI, K., BENEDICT, T., MCMANUS, C.M., BISHOP, O., UNDERWOOD, K., YANKLEY, A., KOSKI, L., SIVY, T.L., and KARPOVICH, D.S., Saginaw Bay Environmental Science Institute at Saginaw Valley State University, 7400 Bay Road, University Center, MI, 48710, USA. **Urban and Rural Contributions of Phosphorus and E. coli to Bad Axe Creek in Huron County, MI.**

Bad Axe Creek is located in Huron County, Michigan and is a tributary of the Pinnebog River, which flows into Saginaw Bay. In this study, samples were collected from several urban and rural sites on Bad Axe Creek and Bad Axe Drain throughout the year under various flow conditions. Onsite measurements included water quality parameters (turbidity, pH, D.O., etc.) using a multi-parameter sonde and stream flow using a Doppler flow meter. Laboratory analysis included nutrients (N and P), suspended solids, and *E. coli* concentrations. From these data, loadings were calculated and compared from site to site. Additionally, quantitative polymerase chain reaction (qPCR) was used to identify sources of contamination using *Bacteroides* target sequences representing human and bovine origins. Total levels of *E. coli* were frequently high at some sites and were independent of temperature and weather conditions. *Bacteroides* source tracking indicated that rural areas had stronger bovine contributions while urban areas had stronger human contamination. Both soluble reactive phosphorus and total phosphorus levels were regularly above the desired concentration for Bad Axe Creek of 60 μg/L at both rural and urban sites.

Keywords: Nutrients, Rural runoff, Microbiological studies, Urban runoff, Watersheds, Bacteria source tracking.

DOKA, S.E.[1], LEWIN, A.[1], DROUIN, R.[2], BENOIT, C.[2], SANDERS, C.[3], PANNUNZIO, G.[3], MONEY, K.[3], BARNUCZ, J.[1], and KOK, S.[4], [1]Fisheries & Oceans Canada, 867 Lakeshore Rd., Burlington, ON, L7S 1A1, CANADA; [2]Ontario Ministry of Natural Resources and Forestry, 659 Exeter Road, London, ON, N6E 1L3, CANADA; [3]Detroit River Canadian Cleanup / Essex Region Conservation, 360 Fairview Ave West, Essex, ON, N8M 1Y6, CANADA; [4]Environment & Climate Change Canada, 867 Lakeshore Rd., Burlington, ON, L7S 1A1, CANADA. **Decision matrix for ranking habitat restoration actions in the Detriot River - Canada.**

Restoration and creation actions are key to improving impaired fish habitats in Areas of Concern. As part of the Detroit River Canadian Remedial Action Plan (RAP) certain sites have been identified for some time as potential sites for restoration. Evaluating those proposed actions in a quantitative way for prioritizing and investing restoration dollars is important. There are ecological, practical and economic methods for the valuation and ranking of physical habitat restoration actions. The Habitat Subgroup of the Canadian RAP created a decision matrix for ranking proposed sites using existing data and newly collected information and by using ecological planning theory with basic landscape principles translated to the aquatic environment. As US partners have focussed on deep water lithophilic habitat restoration, our primary focus was then to target projects in shallow coastal areas that focus on lost shoreline features. As many of the habitat variables of importance for fish during different life stages are being mapped this decision matrix will be useful in future to identify new sites, actions and best practices as the RAP moves forward with delisting impaired fish habitat that benefits both fisheries and aquatic diversity in this important connecting channel system. *Keywords: Habitats, Remediation, Fish.*

DOLGOVA, L.[1], HEBERT, C.[2], and POPP, B.[3], [1]Carleton University, Ottawa, ON, CANADA; [2]Environment and Climate Change Canada - National Wildlife Research Centre, Ottawa, ON, CANADA; [3]University of Hawaii, Honolulu, HI, USA. **Comparing Mercury Levels in Gull Eggs from Different Lakes Using Amino Acid-Specific δ15N Analysis.**

Top predator bird species serve as useful indicators of environmental conditions. Eggs of colonial waterbirds, e.g. gulls, have been used in this capacity for decades across a variety of Canadian ecosystems. An important aspect of this work has been to monitor levels of biomagnifying contaminants like mercury (Hg) in the environment and evaluate spatial patterns to better understand potential sources. However, factors such as differences in diets of birds will affect the levels of contaminants across landscapes; Hg concentrations in eggs

will increase with trophic position. Trophic position can be evaluated by measuring stable nitrogen isotopes ($\delta^{15}N$) in eggs but comparing $\delta^{15}N$ values across sites is not appropriate without considering possible inter-site differences in baseline $\delta^{15}N$ values. We resolve this using amino acid compound-specific nitrogen isotope analysis (AA-CSIA) to generate both baseline and trophic $\delta^{15}N$ values from the same sample. The resulting isotope data are corrected for baseline differences providing the means to compare nitrogen isotope values across sites. Here, we focus on applying AA-CSIA to better understand factors regulating spatial differences in waterbird egg mercury levels collected from several western Canadian lakes over a latitudinal gradient. *Keywords: Mercury, Environmental contaminants, Stable isotopes.*

DOMSKE, H.M., New York Sea Grant, 229 Jarvis Hall, SUNY Buffalo, Buffalo, NY, 14260, USA. **Center for Great Lakes Literacy: An Engaged Network of Educators, Scientists, and Students.**

The Great Lakes Sea Grant Network's Center for Great Lakes Literacy (CGLL) works toward improving the sustainability of Great Lakes watersheds by enhancing the stewardship ethic of students and stakeholders from around the basin. Utilizing programs such as an innovative shipboard program on the Lake Guardian that links researchers and educators; experiential professional development workshops and effective community-school partnerships, CGLL is working to strengthen Great Lakes Literacy and place-based education. CGLL works in partnership with the USEPA's Great Lakes National Program Office and the Great Lakes Restoration Initiative to develop a vibrant network of educators and scientists who are involved in action-oriented Great Lakes stewardship and restoration activities. The presentation will highlight the methodology used to build understanding about critical Great Lakes restoration issues and concepts utilizing the seven Great Lakes Literacy Principles that are integrated into each of CGLL's workshops and other educational practices. Learn about the Center and its award-winning programs designed to improve Great Lakes education around the basin. *Keywords: Outreach, Education, Great Lakes basin.*

DONAHUE, M.J., AECOM, 27777 Franklin Road, Suite 2000, Southfield, MI, 48034, USA. **A Binational Rapid Response Plan for Aquatic Invasive Species.**

A study for the International Joint Commission culminated in North America's first comprehensive Rapid Response Plan to eradicate/control established populations of Aquatic Invasive Species (AIS) in the binational Great Lakes Basin. Components included development of a Policy Framework; a Gap Analysis of the 2009 Asian Carp eradication effort in the Chicago Area Waterways System; a Jurisdictional Analysis to assess rapid response capabilities; and a comprehensive Rapid Response Plan. The latter showcases the importance of an Early Warning System for AIS invasions. Drawing from Incident

Command System methodology, the Plan features a 14 step process to guide chemical, mechanical and/or biological eradication and control actions. Focused on the Lake St. Clair-Lake Erie Corridor as a pilot study, this initiative addressed objectives calling for an early warning system that features detection and reporting, a risk assessment, a decision-making and response protocol, and a mechanism for continuous plan assessment and adaptive management. An inclusive planning process involved an extensive literature search, individual interviews, focus groups and "table top" exercises involving numerous partners. Collectively, this informed dialogue concerning implementation of Annex 6 of the Great Lakes Water Quality Agreement. *Keywords: Invasive species, Early warning system, Planning, Rapid response, Policy making, Binational.*

DORAN, P.J.[1], APSE, C.[2], and MEDARD, M.[3], [1]The Nature Conservancy, Lansing, MI, 48906, USA; [2]The Nature Conservancy, Portland, ME, USA; [3]The Nature Conservancy, Mwanza, TANZANIA. **African Great Lakes: Conservation and Development in a Changing Climate.**

Each of the African Great Lakes provides critical needs for people--domestic, urban and industrial use, waste disposal, and reservoirs for hydropower generation and irrigation. In addition, the lakes support incredible biodiversity as well as support a fishery that provides high quality protein and employment. However, the lakes face threats from unsustainable fishing, invasive species, habitat degradation, urban and industrial pollution, and sedimentation caused by deforestation and agriculture. In addition, many of these pressures are exacerbated due to the highest population growth rates in Africa, compounded by an increasing variability and change in climate that could threaten the water security and human well-being of much of sub-Saharan Africa. In this presentation, we will report out on an African Great Lakes Conference recently convened in early May 2017. The conference represents the start of a process that advances sustainable development solutions across basins and brings long-term attention to cross-basin work. Discussions centered around - Ecosystem Services and Biodiversity Benefits; Sustainable Fisheries and Aquaculture; Climate Change; Population Dynamics, Health and the Environment; Balancing Conservation and Development; and, Governance and Financing. *Keywords: Climate change, Governance, Conservation, Ecosystem services, Africa, Development.*

DOUD, G.E., HOLDA, T.J., WATKINS, J.M., and RUDSTAM, L.G., Cornell University Department of Natural Resources, 110 Fernow Hall, Ithaca, NY, 14853, USA. ***Mysis diluviana* densities between different net tow methods in the Great Lakes.**

Current standard *Mysis diluviana* collections are done at night under red light and a darkened ship with a large (at least 1-meter diameter and at least 250 micron mesh) vertical plankton net towed through the *Mysis* layer (typically 20-60 m). However, from 1998 to 2006, mysids were collected in the survey's standard zooplankton tows at night. The EPA's standard zooplankton sampling employs a 153 micron mesh, 0.5-meter diameter vertical plankton nets towed from as deep as 100 meters and with light on deck. We investigated if *M. diluviana* densities collected by these two methods are sufficiently correlated to justify using historic standard zooplankton samples to reconstruct mysid densities prior to implementation of targeted mysid sampling methods. We also compared size structure of mysids observed by the two methods. We used paired data for standard zooplankton and mysid samples taken from Lakes Superior, Huron, Michigan, and Ontario for EPA GLNPO monitoring in 2012, 2013, and 2014. We will use the correlation between the two net tows and its variability to estimate mysid densities back in time through 1998 and estimate the increased uncertainty associated with using the smaller net and well-lit deck to sample mysids. *Keywords: Zooplankton, Mysids, Crustaceans, Densities.*

DOW, B.A. and JANSSEN, J.A., University of Wisconsin-Milwaukee, 600 E Greenfield Avenue, Milwaukee, WI, 53204, USA. **Assessment and Mapping of the Milwaukee Estuary Habitat.**

With minimal habitat management, the Milwaukee Harbor has developed a diverse fishery for seasonal variety of both warm water game species, such as black basses, as well as salmonid species. Milwaukee Harbor's brown trout fishery is world class, with the IGFA catch and release world record coming from the harbor in 2011. When Milwaukee was founded its estuary was a significant source of both commerce and recreational activity. Subsequent industrial development greatly diminished the fishery, but in response to the Clean Water Act and redevelopment efforts, new opportunities exist for a truly functional estuary - one in which industry, ecological services and human activities co-exist in a novel ecosystem. Currently, landscape architects focus on the shoreline of the estuary; but to plan fish habitat improvement using an ecosystem approach, managers need to know what is underwater. Our assessment focuses on the diversity and location of fish forage and habitat. Preliminary data includes 66 km of shoreline mapped with sidescan sonar, totaling to 1.77 sq. km of seven different substrate categories throughout the Milwaukee Estuary. Fine (64.86%), rocky boulder (10.80%), rocky fine (10.81%), and wood/steel piling(s) (9.65%) are the most prevalent substrate classes. A major final product will be an accessible layered habitat map. *Keywords: Lake Michigan, Milwaukee Estuary, Fish, Habitats.*

DRAG, N., Alliance for the Great Lakes, 640 Ellicott St, Suite 439, Buffalo, NY, 14203, USA. **Citizen Science Datasets Reveal Drivers of Spatial and Temporal Variation for Anthropogenic Litter.**

Based on research done by Dr. Tim Hoellein and the Alliance for the Great Lakes, this presentation will present an analysis of the composition, abundance, and location of anthropogenic litter (AL) found on Great Lakes and collected by Adopt-a-Beach volunteers. This research is a model for utilizing datasets collected by volunteers involved in citizen science programs. It also contributes to AL management by offering priorities for AL types and locations to maximize AL reduction. *Keywords: Citizen science, Adopt-a-Beach, Marine debris, Great Lakes basin.*

DROUILLARD, K.G.[1], LAFONTAINE, J.[1], GRGICEK-MANNION, A.[1], MCPHEDRAN, K.[2], SZALINSKA, E.[3], and HAFFNER, G.D.[1], [1]GLIER, University of Windsor, 401 Sunset Ave, Windsor, ON, N9B3P4, CANADA; [2]University of Saskatchewan, 57 Campus Dr, Saskatoon, SK, S7N 5A9, CANADA; [3]AGH University of Science and Technology in Krakow, aleja Adama Mickiewicza 30, Krakow, 30-059, POLAND. **Sediment contamination in the Huron-Erie Corridor and linkages to AOC beneficial use impairments.**

Contaminated sediments in the St. Clair and Detroit River Areas of Concern have long been recognized as a source of beneficial use impairments (BUI).Spatial surveys of sediment contamination were commenced in the mid-1980's via the Upper Great Lakes Connecting Channel's Study. This work provided documentation of some of the most contaminated areas within the two AOCs and was the basis of many of the original BUI assessments. In 1999, the first river-wide survey of sediment contamination was conducted in the Detroit River by GLIER, University of Windsor. The survey included 150 sampling stations equally divided between countries and distributed according to a stratified random design. The survey provided a holistic assessment of contaminant inventories in the Detroit River and has since been utilized by both Canadian and U.S. partners in addressing BUI assessments and delisting criteria. Since that time, several additional surveys were completed covering the Detroit, St. Clair and entire Huron-Erie corridor in collaboration with Canadian and U.S. agencies. In addition to sample collection, novel methods of data interpretation were applied including advanced-GIS and multi-pollutant indices that facilitated multi-partner cooperation and led to the designation of a set of mitigation priority zones in the Detroit River. *Keywords: Sediment quality, Decision making, Environmental contaminants.*

DUAN, X. and DIONYSIOU, D.D., University of Cincinnati, Cincinnati, OH, USA. **Destruction of Cyanotoxins by Chlorination and UV/Chlorine Processes.**

Considering the wide utilization of both germicidal UV system and chlorination process in water treatment facilities for disinfection purposes, the coupling of UV-254 nm with chlorination to achieve both disinfection and organic chemical removal has been attracting attention in its potential application in water purification. In this study, UV/chlorine process was employed to degrade Microcystin-LR and Cylindrospermopsin in source water. Compared to UV irradiation or chlorination alone, their combination significantly lowered the chemical and energy demand mainly because of the rapid formation of chlorine and hydroxyl radicals. While chlorination is not effective at high pH (8-10) or in the presence of natural organic matter, UV/Chlorine process could still achieve efficient toxins removal under those circumstances. Lower chlorinated byproducts were observed in the decomposition by UV/chlorine than by chlorination at the same oxidant dose. In conclusion, UV/Chlorine process provides an effective method for the destruction of cyanotoxins in contaminated water *Keywords: Toxic substances, Ultraviolet radiation.*

DUAN, Y.J.[1], MADENJIAN, C.P.[2], XIE, C.X.[1], DIANA, J.S.[3], O'BRIEN, T.P.[2], ZHAO, Y.M.[4], HE, J.X.[5], FARHA, S.A.[2], and HUO, B.[1], [1]Huazhong Agricultural University, College of Fisheries, Wuhan, 430070, CHINA; [2]USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105, USA; [3]University of Michigan, School of Natural Resources and Environment, Ann Arbor, MI, 48109, USA; [4]Ontario Ministry of Natural Resources, Aquatic Research and Development Section, Wheatley, ON, N0P 2P0, CANADA; [5]Michigan Department of Natural Resources, Lake Huron Research Station, Alpena, MI, 49707, USA. **Age and Growth of Round Gobies in Lake Huron: Implications for Food Web Dynamics.**

Although the round goby (*Neogobius melanostomus*) has become established throughout the Laurentian Great Lakes, information is scarce on spatial variation in round goby growth between and within lakes. Based on a sample of 754 specimens captured in 2014, age, growth, and mortality of round gobies at four locations (Hammond Bay, Rockport, Thunder Bay, and Saginaw Bay) in Lake Huron were assessed via otolith analysis. Total length (TL) of round gobies ranged from 44 to 123 mm, and estimated ages of round gobies ranged from 2 to 7 years. Sex-specific, body-otolith relationships were used to back-calculate total lengths at age, which were then fitted to von Bertalanffy growth models. For each sex, round goby growth showed significant spatial variation among the four locations within Lake Huron. At all four locations in Lake Huron, males grew significantly faster than females and attained a larger asymptotic length than females. Annual mortality rate estimates were high (62 to 85%), based on catch-curve analysis, suggesting that round gobies may be under predatory control in Lake Huron. We compared our results with those from a previous study on Lake Michigan, and we concluded that Lake Michigan round gobies grew significantly faster than Lake Huron round gobies. *Keywords: Round goby, Age and growth, Life history studies, Mortality, Food chains.*

DUFOUR, M.R.[1], ROSEMAN, E.R.[2], PRITT, J.J.[3], FISCHER, J.L.[2], DEBRUYNE, R.L.[2], and BENNION, D.H.[2], [1]Michigan State University, 480 Wilson Rd., East Lansing, MI, 48824, USA; [2]U.S. Geological Survey - Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105, USA; [3]Ohio DNR - Division of Wildlife, 10517 Canal Rd. SE, Hebron, OH, 43025, USA. **Estimating Detroit River larval walleye export with a Bayesian hierarchical state-space model.**

The Detroit River has been channelized extensively, altering flow dynamics and potentially harming larval walleye transport to nursery areas. Channelization has concentrated 67% of the Detroit River discharge through the Livingstone and Amherstburg shipping channels, two of the five distributaries. We evaluated larval walleye [*Sander vitreus*] export dynamics using spatially and temporally distributed larval samples and a Bayesian hierarchical state-space model. Although extensive effort was used to collect larvae, data were sparse and variable over the day-channel scale of interest. However, density estimates were improved by sharing information between days, and assuming exchangeability among variance parameters across channels within days. Daily mean density estimates tracked sample data, even under scenarios with little day-channel specific data. Channel specific export varied across years; however, most larvae were exported through the highly-modified shipping channels. Concentrated discharge in shipping channels may increase mortality by transporting larval fish off-shore, away from nearshore nurseries (i.e., aberrant drift). Connectivity between spawning and nursery habitats could be improved by restoring flow dynamics to increase larval retention in nearshore areas. *Keywords: Detroit River, Bayesian, Fish, Hierarchical, Walleye, State-space.*

DUMITRIU, I.[1], SPACHER, P.[1], and HALFMAN, J.D.[2], [1]Hobart & William Smith Colleges, Dept Physics, Geneva, NY, 14456, USA; [2]Hobart & William Smith Colleges, Dept Geoscience / Environmental Studies, Geneva, NY, 14456, USA. **Drone Quantification of Algal Distributions and Concentrations in Lakes.**

Water quality issues like blue-green algae blooms (and HABs) have negatively affected the Finger Lakes (FLs) in central New York. The oligotrophic to eutrophic FLs experience similar water quality issues as the Great Lakes, thus they provide an ideal natural laboratory to investigate issues impacting the Great Lakes but are smaller thus easier to study. This poster presents preliminary research using drones to map algal blooms. Two drones, DJI's Matrice 100 with a gimbaled Zenmuse Z3 camera and DJI's Phantom 3 Advanced with a Sony EXMOR gimbaled camera, captured 12 megapixel photographs, each photo spanning an area of 200 by 300 m from an altitude of 100 m. The 2016 effort investigated, for example, sequential, georeferenced, overlapping, nearshore photographs that mapped the spatial and temporal character of nearshore algae and other plants, e.g., *cladophera*. Each digital image also captured the blue, green and red bands of the color spectrum. The green-to-blue band ratios of offshore photographs were proportional to 1/ln(Secchi disk depths) and chlorophyll-a concentrations. Future research will assess the impact of the glare of the sun, camera tilt angle, cloudiness, and wind driven waves on image quality. Introduction of full spectrum images to understand the distribution of algal assemblages is planned for 2017. *Keywords: Algae, Drones, Remote sensing, Water quality.*

DUNGAVELL, J.A., Ontario Ministry of Natural Resources and Forestry, 300 Water Street, Peterborough, ON, K9H4W2, CANADA. **Implementation of the Sustainable Water Resources Agreement in the Province of Ontario.**

Ontario contains portions of four of the five Great Lakes watersheds as well as part of the St. Lawrence River watershed. There are approximately 2,056 km of basin boundary within the province. In 1999, the Government of Ontario banned the transfer of water out of its three primary watersheds. Following the signing of the Great Lakes-St. Lawrence River Basin Sustainable Water Resource Agreement in 2005, the province passed implementing legislation, the *Safeguarding and Sustaining Ontario's Water Act, 2007*, that maintained the overall ban on diversions out of the Great Lakes Basin and elevated it into law. In 2015, Ontario passed its supporting regulation on intra-basin transfers allowing the Agreement to come into full force. Since the signing of the Agreement, the province has continued to make progress on meeting all terms of the Agreement related to water management and conservation objectives and programs. This presentation will provide an overview of the implementation of the Agreement in Ontario and highlight key examples of work completed to date. *Keywords: Great Lakes basin, Conservation, Regulations.*

E

EDWARDS, K.A.[1], BAEUMNER, A.J.[2], and KRAFT, C.E.[1], [1]Cornell University, Department of Natural Resources, Ithaca, NY, 14853, USA; [2]University of Regensburg, Regensburg, GERMANY. **Nature recognizing nature: Relying on bacteria-derived proteins for thiamine analysis.**

Thiamine (vitamin B1) is essential to the health of nearly all living organisms, serving as an enzyme cofactor for numerous metabolic processes. Deficiency in thiamine has had a marked impact on the health of salmonine fishes in the Great Lakes and other bodies of water, including the Finger Lakes and Baltic Sea. Early Mortality Syndrome, Cayuga Syndrome, and M74 syndrome all are related to thiamine deficiency and yield morbidity and mortality especially during developmental stages of fish. To improve the throughput and reduce costs associated with traditional HPLC-based thiamine analysis, we have developed a competitive binding assay for thiamine in a microtiter plate format. This assay relies on a protein sourced from *Escherichia coli* for thiamine recognition and has been demonstrated to have exceptional specificity towards thiamine versus its fragments or analogues. We will describe the development, benefits and caveats of this analytical approach, as well as applications of this assay to measure thiamine in environmental waters and other biological matrices. *Keywords: Vitamin B, Thiaminase, Chemical analysis.*

EGAN, K.J. and VONDER MEULEN, N., University of Toledo, Toledo, OH, 43606, USA. **Benefit-Cost Analysis for Policy Options (e.g., fertilizer fee, wetlands) to Reduce Nutrient Runoff.**

This paper looks at using surface flow and subsurface flow wetlands, sediment ponds, phosphorous removal structures, and a phosphorous corrective fee as cost-effective solutions to reduce phosphorous loadings into Lake Erie from the Maumee River Watershed (MRW). Phosphorous is a leading nutrient in aiding the production of algal blooms in Lake Erie. A full Benefit-Cost Analysis (BCA) for the different solutions was conducted, with a phosphorous loading target reduction of 10%. Surface flow wetlands and the phosphorous corrective fee were found to be the most efficient. As a result, a combination of the two solutions, each reducing 20% Total Phosphorous (TP), is recommended to reach the targeted 40% phosphorous reduction in the MRW. *Keywords: Economic evaluation, Lake Erie, Environmental policy, Harmful algal blooms.*

ELGIN, A.K.[1], BURLAKOVA, L.E.[2], KARATAYEV, A.Y.[2], MEHLER, K.[2], and NALEPA, T.F.[3], [1]NOAA GLERL, 1431 Beach St, Muskegon, MI, 49441, USA; [2]Great Lakes Center, Buffalo State College, 1300 Elmwood Ave, Buffalo, NY, 14222, USA; [3]Water Center, University of Michigan, Ann Arbor, MI, 48104, USA. **Quagga Mussel Body Condition and Size Distribution Inform Recent Lake Michigan Population Trends.**

Since the rapid expansion of quagga mussels (*Dreissena r. bugensis*) in Lake Michigan, the lake has exhibited mussel-induced changes, most notably in the availability of phytoplankton. Ultimately, this can cause food limitation for the mussels themselves. We will present data on quagga mussels from the NOAA long-term, annual benthic surveys in southern Lake Michigan (1998-present). In recent years, the quagga population has shown signs of decline in mid-depth regions (30-90m), coinciding with decreased relative weight (i.e. ash-free dry tissue weight per unit shell length), and signs of low recruitment of small size classes. At sites >90m, population growth has been slow and steady, but the population is dominated by small mussels and the transition to larger sizes is limited. We will also present lake-wide patterns in length-weight relationships from the 2015 CSMI Lake

Michigan benthic survey. We found quagga mussels to have the highest relative weight in the nearshore zone (<30m), which decreased in the mid-depth zone between 30-90m, and increased to a moderate level at sites >90m. We also detected a south>central>north regional trend in relative weight. Changes in mussel size structure and body condition, in conjunction with population density, provide insights into observed quagga mussel population dynamics. *Keywords: Dreissena, Invasive species, Populations.*

ELLIOTT, C.[1], HOLDEN, J.P.[2], HOYLE, J.A.[2], and TUFTS, B.[1], [1]Department of Biology, Queen's University, Barrie Street, Kingston, ON, K7L 3N6, CANADA; [2]Lake Ontario Management Unit, Ontario Ministry of Natural Resources and Forestry, Hatchery Lane, Picton, ON, K0K 2T0, CANADA. **Age, Growth and Recruitment of Black Crappie (*Pomoxis nigromaculatus*) in Southeastern Ontario.**

Black Crappie (*Pomoxis nigromaculatus*) is an important species in Ontario's recreational fisheries. At the present time, however, there is still much to be learned about the biology of Black Crappie populations in Ontario. This project examines how temperature affects growth and recruitment of Black Crappie in several different waterbodies in Southeastern Ontario. To date, physical measurements and ageing structures have been collected from 71 individuals in two different lakes in the Kingston region. Otoliths were used for age determination since it has previously been demonstrated that they provide the most reliable information for ageing this species. The mean age within the samples collected to date was 5.3 yrs with a maximum age of 11 yrs. Using the measured variables, further analyses will examine the relative year-class strength, age-at-length, and recruitment of the species. Additional samples will also be collected from Lake Ontario for comparison with samples from smaller lakes. It is anticipated that this study will provide important information about the age structure of Black Crappie populations in this region, as well as the impact of temperature on growth and recruitment that may be useful for the future management of this species in Ontario. *Keywords: Recruitment, Black Crappie, Life history studies, Age distributions, Fishing, Growth distributions.*

ELLIOTT, S.M.[1] and VANDERMEULEN, D.D.[2], [1]U.S. Geological Survey, 2280 Woodale Drive, Mounds View, MN, 55112, USA; [2]U.S. National Park Service, 2800 Lakeshore Dr. E., Ashland, WI, 54806, USA. **Emerging Contaminants In National Park Surface Waters: A Reconnaissance Study.**

A reconnaissance study was initiated in 2013 to identify the presence of emerging contaminants such as pharmaceuticals, personal care products, and pesticides in surface waters located within U.S. national parks. During 2013-2016, water samples were collected from lakes and rivers of six national parks within the Great Lakes Network: Mississippi

National River and Recreation Area, Apostle Island National Lakeshore, Isle Royale National Park, Pictured Rocks National Lakeshore, Indiana Dunes National Lakeshore, and Sleeping Bear Dunes National Lakeshore. More chemicals were detected at the two more urban influenced parks, and at higher concentrations. Atrazine and DEET were consistently detected at more remote national parks, albeit at relatively lower concentrations. Taking into account the number of chemicals analyzed, pesticides were detected at a higher rate than other chemicals. Although environmental concentrations rarely exceeded standards or reference values, hydrochlorothiazide (diuretic) exceeded a human health-based screening value in several samples collected from the Mississippi River. Results from this study are being used to establish a baseline of emerging contaminants in Great Lakes Network national park surface waters and evaluate the threat emerging contaminants pose to national park aquatic resources. *Keywords: Water quality, U.S. National Parks, Emerging contaminants.*

ELLISON, R.[1], NOFFKE, S.[2], FOOSE, M.[3], and BURNS, R.L.[4], [1]USEPA GLNPO, 9311 Groh Rd, Grosse Ile, mi, 48138, USA; [2]MDEQ WRD, 525 West Allegan St., Lansing, mi, 48933, USA; [3]MDEQ OGL, 27700 Donald Ct., Warren, mi, 48092, USA; [4]Friends of the Detroit River, 20600 Eureka Rd, Taylor, mi, 48180, USA. **Determining Nature and Extent of Contaminated Sediment in a Large, Urban, High Flow Environment.**

The Detroit River is a bi-national waterway. The shoreline along most of the US side has been highly industrialized for over a century. With multiple active and historic sources of sediment contamination throughout its 32 miles legacy contaminants remain in the sediments at levels that continue to negatively affect the river's beneficial uses, even with an average flow rate of 180,000 cubic feet/sec. In order to address impairments to beneficial uses in the Detroit River Area of Concern, the US Environmental Protection Agency, Michigan Department of Environmental Quality, and Detroit River Area of Concern Public Advisory Committee lead a multi-year effort to identify and characterize sediment contamination in the river that is likely contributing the rivers' degradation. This presentation details the numerous partnerships, historic research, modeling, and database analysis that made it possible to identify zones of contamination throughout the river, and presents the results of the sediment characterization of these zones. The culmination of this effort will be a strategic plan that targets specific contaminated hot spots in the river for further delineation and possible remediation to address the remaining beneficial use impairments that continue to be affected by these contaminated hot spots.
Keywords: Sediments, Remediation, Detroit River.

EMBKE, H.[1], QIAN, S.S.[1], KOCOVSKY, P.M.[2], and MAYER, C.M.[1], [1]University of Toledo, Toledo, OH, 43606, USA; [2]U.S. Geological Survey, Sandusky, OH, 44870, USA. **A**

Bayesian Modeling Framework for Identifying Conditions Favorable for Grass Carp Spawning.

Since the discovery of grass carp spawning in Sandusky River, a Lake Erie tributary, efforts have been focused on identifying conditions favorable for grass carp spawning to support the development of effective management strategies. However, the sparsity of data, as well as the low detection probability, made the conventional statistical modeling approach an unlikely choice. We present a Bayesian model combining information from three sources -- mechanistic modeling results, expert knowledge, and observational data -- to learn about the climate and flow conditions favorable for spawning. The mechanistic model provides information on the likelihood of detecting grass carp eggs when they are present in the river; expert knowledge (including previous sightings of adult and juvenile grass carp) provides basis for eliciting prior probabilities of grass carp spawning under different conditions; and data from two years sampling effort enabled the updating of the prior probabilities to provide the basis for designing an optimal sampling plan. Additional data from future sampling effort can be used to update and refine the model. *Keywords: Invasive species, Modeling, Lake Erie.*

ENGEL, D.D., KOWALSKI, K., and BICKFORD, W.A., USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105, USA. **New Approaches to an Old Problem: Innovative Techniques for *Phragmites* Management.**

The non-native *Phragmites australis* (hereafter *Phragmites*) is a perennial grass that has invaded wetlands throughout the Great Lakes basin. *Phragmites* grows robustly and can alter the structure and function of wetlands, leading managers to spend millions of dollars every year in control efforts. However, current management techniques often lack long-term success, can significantly impact non-target species, and regularly require extensive follow-up. Therefore, scientists at the U.S. Geological Survey and several universities (Michigan, Indiana, Rutgers, Wayne State) are developing innovative techniques that could lead to targeted yet sustainable management approaches. Here, we report on two new *Phragmites* -management techniques grounded in principles of microbial symbiosis and gene silencing. We will discuss the status of current efforts, highlight future directions, and summarize our vision for their application. Our goal for these techniques is to provide managers with additional tools for their integrated pest management strategies that are sustainable and more environmentally friendly. *Keywords: Phragmites australis, Management, Wetlands.*

ENNS, G.E.[1], COLBORNE, S.F.[1], FISK, A.T.[1], NIGHTINGALE, M.[2], MAYER, B.[2], and MUNDLE, S.O.C.[1], [1]Great Lakes Institute for Environmental Research, University Windsor, 401 Sunset Ave., Windsor, ON, N9B 3P4, CANADA; [2]Department of

Geoscience, University of Calgary, 2500 University Drive NW, Calgary, AB, T2N 1N4, CANADA. **Investigating the Distribution and Deposition of Nutrients in the Detroit River.**

Geochemical tracers (compositional and isotopic) can be used to identify the sources, transport pathways, and biogeochemical processes that affect nutrient dynamics in river water and sediments. Point and non-point sources of urban and industrial pollution increase along the flowpath of the Detroit River. Limited information is available characterizing the relationship between the distribution of dissolved nutrients transported in river water with the deposition and biogeochemical cycling of these carbon, nitrogen, sulfur, and phosphorus inputs in river sediments. Sediment and water (one meter above the sediments) samples were collected from 23 locations across 8 transects covering the 45-km path of the Detroit River. Sampling included both the Canadian and American shorelines and shipping channels. The transects were distributed from Lake St. Clair to Lake Erie targeting areas with probable low and high levels of contaminant inputs from industrial and urban sources. Compositional and isotopic (δ13C, 2H, 18O, 15N and 34S) indicators were used to identify nutrient sources and characterize their distribution in the river water and sediments. The spatial variability of nutrients corresponded well with the anticipated anthropogenic sources related to urbanization and industrial activity along the Detroit River.
Keywords: Nutrients, Isotope studies, Water quality.

ERICKSON, K.[1], FUHRMANN, P.[1], ROCKWELL, C.R.[1], DICK, G.O.[2], and SHEARER, J.F.[2], [1]Ecology and Environment, Inc., 368 Pleasant View Drive, Lancaster, NY, 14086, USA; [2]U.S. Army Engineer Research and Development Center, 3909 Halls Ferry Road, Vicksburg, MS, 39180-6199, USA. **Times Beach Aquatic and Riparian Invasive Plant Species (AIS) Control Demonstration Project.**

The Times Beach AIS Demonstration Project, located within the Niagara River Area of Concern, was designed to test three herbicide regimes (glyphosate, imazamox, and a combination) to control Phragmites. The Project Team has members from public and private sectors, and cooperated with a variety of regional stakeholders at local, county, and state levels. The five-year project (2012-2016) monitored not only AIS treatments but also the vegetation and avian communities. To successfully control Phragmites infestations, it is important to use the response of biological communities to quantify project success (Martin and Blossey 2013). Monitoring results guided adaptive management regarding AIS treatments and species selection and locations of native restoration plantings. The Phragmites biomass removed from the site decreased in each successive year; cover and frequency of Phragmites dramatically decreased and increased for other plant species; and species richness increased in the vegetation and avian communities. Coordination with

stakeholders is essential to ensure a successful transfer of management responsibilities, with the desired result of maintaining habitat quality through long-term invasive species management. The project has produced data that can be applied to other Great Lakes sites impacted by Phragmites. *Keywords: Biomonitoring, Phragmites australis, Lake Erie.*

ERLER, A.R.[1], FREY, S.K.[1], PELTIER, W.R.[2], and SUDICKY, E.A.[1], [1]Aquanty Inc., 564 Weber St. N., Waterloo, ON, N2L5C6, CANADA; [2]University of Toronto, 60 St. George St., Toronto, ON, M5S1A7, CANADA. **Coupling Regional Climate Projections with an Integrated Hydrologic Model to Assess Water Resources.**

The impact of climate change on water resources is of great interest to researchers and stake holders. However, hydrologic projections are predominantly forced with output from low-resolution Global Climate Models, which typically have minimal or no representation of the Great Lakes. Furthermore, heavily parameterized surface water models are often employed in climate projection studies to integrate terrestrial hydrologic process, for which process simplification induces serious limitations under the non-stationarity hypothesis. To address these limitations, we employed an ensemble of dynamically downscaled climate projections generated with the WRF model at up to 10km resolution, in conjunction with a high resolution HydroGeoSphere (HGS) model in order to predict the long term behavior of surface and groundwater resources within the Grand River Watershed. The Great Lakes are represented within WRF by the fully coupled lake model FLake. The HydroGeoSphere model for the terrestrial hydrosphere incorporates a highly resolved surface water and groundwater flow domain into a physics based fully coupled flow solution. Hydro-climatological projections based on the RCP8.5 GHG scenario for mid- and end-century time periods will be presented so as to demonstrate the applicability of the coupled, physics based modeling approach. *Keywords: Watersheds, Hydrologic modeling, Hydrologic cycle, Dynamical downscaling, Climate change, Regional climate modeling.*

EUCLIDE, P.T. and MARSDEN, J.E., University of Vermont, RESL 3 College Street, Burlington, VT, 05401, USA. **Movement of walleye in Lake Champlain inferred from forty years of mark-recapture data.**

Walleye support a popular recreational fishery in many North American lakes including Lake Champlain, Vermont. To manage walleye populations for recreational use, it is important to understand how walleye interact with the environment. In Lake Champlain, habitat fragmentation by lake causeways is hypothesized to impede walleye migration to foraging and spawning habitat. To test the hypothesis that causeways restrict walleye movement, we examined the temporal and spatial patterns in recapture locations of four walleye spawning groups in Lake Champlain. Patterns were identified using mark and

recapture data collected by the Vermont Fish and Wildlife Department dating back to the 1960s. Walleye recaptured during spring were generally recaptured in the same river that they were tagged in a previous year. However, when walleye strayed to a different river, distance appeared to predict recapture spawning site better than the presence of a causeway. Walleye recaptured outside of a spawning site were generally recaptured within the same basin in which they were tagged suggesting limited movement through causeways. Our results from over 40 years of mark and recapture data of walleye suggest that causeways may impede walleye movement in Lake Champlain but indicate that dispersal through causeways to new spawning sites still occurs. *Keywords: Lake Champlain, Habitat fragmentation, Walleye.*

EVANOFF, P.[1], BLICHARSKI, T.[2], BOHLING, M.E.[3], BURNS, R.L.[2], and LOVALL, S.[2], [1]SmithGroupJJR, Detroit, USA; [2]Friends of the Detroit River, Taylor, USA; [3]Michigan Sea Grant, Southgate, USA. **Detroit River AOC Projects on Belle Isle.**

Tbd Keywords: Habitats, Restoraion, Coastal wetlands, GLRI, Detroit River.

EVANS, A.N.[1], ZAJICEK, J.L.[2], RILEY, S.C.[3], RICHTER, C.A.[2], RINCHARD, J.[4], KRUEGER, C.C.[5], TILLITT, D.E.[2], and HEPPELL, S.A.[1], [1]Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR, 97331, USA; [2]U.S. Geological Survey, Columbia Environmental Research Center, Columbia, MO, 65201, USA; [3]U.S. Geological Survey, Great Lakes Science Center, Ann Arbor, MI, 48105, USA; [4]Department of Environmental Science and Biology, The College at Brockport - SUNY, Brockport, NY, 14420, USA; [5]Center for Systems Integration and Sustainability, Michigan State University, East Lansing, MI, 48823, USA. **Thiaminase Activity of Great Lakes Zooplankton is not Related to Zooplankton Community Composition.**

Thiamine (vitamin B1) Deficiency Complex in salmonids is caused by consumption of prey fishes containing high levels of thiaminase, a thiamine-degrading enzyme. The source of the thiaminase enzyme in Great Lakes prey fishes is unknown. Prey fishes may obtain thiaminase from their diet, and zooplankton contain thiaminase activity. We described the distribution of thiaminase activity in three size fractions of zooplankton and evaluated the degree to which thiaminase activity varies by collection site, season, depth, and size fraction. We tested the hypothesis that thiaminase activity in bulk zooplankton is related to zooplankton community composition, with the goal of identifying zooplankton taxa that were consistently abundant in samples with high thiaminase activity and absent or at low abundance in samples with low thiaminase activity. We compared thiaminase activity in bulk plankton tows to the species composition in tows using three multivariate procedures, Nonmetric Multidimensional Scaling, distance-based Redundancy Analysis, and Indicator Species Analysis (ISA). Only ISA revealed a potential candidate source of thiaminase activity, Ploesoma spp. Our findings argue against the suggestion that any single zooplankton taxon is consistently the source of thiaminase across all plankton communities in the Great Lakes. *Keywords: Vitamin B, Zooplankton, Thiaminase.*

EVANS, K.M., West Michigan Shoreline Regional Development Commission, 316 Morris Avenue, Muskegon, MI, 49440, USA. **Planning for Life After Delisting for the Muskegon Lake Area of Concern.**

Muskegon Lake, located along the east shoreline of Lake Michigan, was designated an Area of Concern in 1985 due to poor water quality, degraded fish and wildlife; contaminated sediments, and groundwater contamination, among other impairments. Cleanup work has been underway since the 1990s and has accelerated under the Great Lakes Legacy Act and Great Lakes Restoration Initiative. Management actions needed to delist the Area of Concern are projected to be completed as soon as 2019. Community-based efforts are underway to plan for "life after delisting," including 1) a Coastal Resiliency Sub-Area Plan to guide local governments and shoreline landowners in implementing climate adaptation strategies; 2) an Ecosystem Management Plan to establish future environmental goals, actions and monitoring needs; and 3) a Muskegon Lake Vision 2020 to guide shoreline development for recreation, ports, natural resources, and residential growth. These efforts are led by the West Michigan Shoreline Regional Development Commission and guided by the Muskegon Lake Watershed Partnership. The presentation will show how this coordinated, strategic process is establishing a community consensus, partnerships and the plans needed to sustain restoration, ensure continued stewardship, and secure multiple benefits from the lake and its water resources. *Keywords: Public participation, Management, Great Lakes Restoration Initiative (GLRI).*

EVANS, M.A.[1], DURIS, J.W.[2], LARSON, J.H.[3], GIVENS, C.E.[4], STELZER, E.A.[4], ECKER, C.D.[4], LOFTIN, K.A.[5], and LENAKER, P.L.[6], [1]USGS Great Lakes Science Center, Ann Arbor, MI, USA; [2]USGS Pennsylvania Water Science Center, New Cumberland, PA, USA; [3]USGS Upper Midwest Environmental Sciences Center, La Crosse, WI, USA; [4]USGS Michigan-Ohio Water Science Center, Lansing, MI, USA; [5]USGS Kansas Water Science Center, Lawrence, KS, USA; [6]USGS Wisconsin Water Science Center, Middleton, WI, USA. **Exploring the Causes of cyanoHABs Initiation and Timing.**

Cyanobacteria blooms (cyanoHABs) have become an annual occurrence in several areas of the Laurentian Great Lakes. Significant research has been conducted exploring controls on bloom size and intensity. However, many questions remain about the causes and timing of bloom initiation and determinants of phytoplankton species composition. Lake Erie *Microcystis* sp. blooms, for example, often seem to be delayed relative to the initiation of bloom favorable water temperature, light, and nutrient conditions. Additional conditions needed to initiate *Microcystis* sp. growth were explored across 4 years (2013-2016) in Lake Erie through time-series sampling at 6 sites. Comparisons across sites and years indicate the timing of mixing events, storm pulses of nutrient loading, and spring warming drive bloom initiation and, potentially, change the course of seasonal phytoplankton community dominance. *Keywords: Eutrophication, Harmful algal blooms, Phytoplankton.*

EVENSON, G.R.[1], JONES, C.N.[1], MCLAUGHLIN, D.L.[1], GOLDEN, H.E.[2], and LANE, C.R.[2], [1]Department of Forest Resources and Environmental Conservation, Virginia Tech, Blacksburg, VA, USA; [2]US EPA Office of Research and Development, Cincinnati, OH, USA. **A Watershed-Scale Hydrologic Model to Simulate Non-Floodplain Constructed Wetlands.**

We present a method for modifying the soil and water assessment tool (SWAT) model to incorporate an improved representation of non-floodplain constructed wetlands. Our method (1) redefines the model's hydrologic response unit spatial boundaries to conform to constructed wetland and associated catchment boundaries, (2) constructs a series of new model input files to direct the simulation of inter-wetland fill-spill and upland-to-wetland hydrologic flows, (3) modifies the model source code to facilitate use of the new SWAT input files, and (4) modifies the model source code to simulate upland-wetland subsurface flows using Darcy's law as dictated by relative upland water-table and wetland-stage relationships. Our method of non-floodplain wetland simulation represents a significant opportunity to evaluate non-floodplain constructed wetlands as means of improving water quality within the Great Lakes and their tributaries. *Keywords: Wetlands, Modeling, Planning.*

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FAI, G.[1], AUSTIN, J.A.[1], and MCKINNEY, P.J.[2], [1]University of Minnesota, Duluth, Duluth, MN, 55812, USA; [2]US EPA, MED, Duluth, MN, USA. **Formation of a wind-drive cross-shelf sediment plume in a large lake.**

In the spring of 2016 a wind event characterized by north eastern winds of up to 15ms^{-1} led to the formation of a significant sediment plume extending tens of kilometers from the western end of Lake Superior. An investigation of historical data shows these types of wind events typically occurring 3 to 4 times each year during the spring season in past years. Satellite images also confirm sediment plume formation in the past during these events. An analytical model was developed for an infinitely long channel with arbitrary bathymetry and an along-axis wind. The steady state solution to this model shows circulation in the direction of wind stress in near-shore shallower areas and a pressure gradient dominated flow against the wind in the deeper areas of the basin. By applying the model to the western arm of Lake Superior, the volume flux through a cross-section of the channel was roughly $10^{10}m^3$ of water was transported from the nearshore into the deeper portions of the lake carrying with it a significant amount of sediment. As the plume progressed a 1C temperature increase was recorded in the entire water column by an offshore meteorology buoy. Optical back scatter data from an off-shore profiler in the western arm showed a high concentration of sediment throughout the entire water column. *Keywords: Sediment transport, Lake Superior, Water currents.*

FAKOURI BAYGI, S.[1], FERNANDO, S.[2], CRIMMINS, B.S.[2], HOPKE, P.K.[2], and HOLSEN, T.M.[2], [1]Department of Chemical and Biomolecular Engineering, 8 Clarkson Avenue, Potsdam, NY, 13699, USA; [2]Center for Air Resources Engineering & Science, 8 Clarkson Avenue, Potsdam, NY, 13699, USA. **Comprehensive Emerging Chemical Discovery: Aromatic Chlorinated and Brominated Compounds in Lake Ont.**

A screening algorithm based on the eXtracted Ion Chromatogram (XIC) method has been developed to search high resolution mass spectrometric data for unknown environmental contaminants. The algorithm calculates the isotopic distribution profile as the main search criteria of the candidate compounds using the number of C, Cl, Br and S atoms. Combinations of 6500 compounds containing C/Cl/Br/S were chosen to check the availability of their theoretical intensity pattern in experimental spectrums. Thereafter, the given number of C/Cl/Br/S is assessed based on the matched isotopic profile. Next, a module is used based on the given number of C/Cl/Br/S and the mass of the most abundant isotopologue to find the number of other atoms including O, H, N, P and ultimately suggests a molecular formula which matches the isotopic profile. Currently, this algorithm may create and search a virtual library containing up to 6.3 million compounds. Lake Ontario trout extract was analyzed by APGC-QToF-MS in negative mode. The generated data file was then processed with the XIC algorithm compiled in the MATLAB scripts. Applying XIC algorithm 32 previously known compounds were detected, including heptachloroquinoline which is used in luminescence and display devices. An additional 22 candidate compounds were also observed requiring further study. *Keywords: Mass spectrometry, Extracted Ion Chromatogram, GC/HRMS, Heptachloroquinoline, Lake Ontario.*

FALES, M.K.[1], WICKERHAM, B.[1], EANES, F.[2], and PROKOPY, L.S.[2], [1]The Nature Conservancy, 101 E. Grand River Avenue, Lansing, MI, 48906, USA; [2]Purdue University, 195 Marsteller Street, West Lafayette, IN, 47907, USA. **The Hard Work of Multi Stakeholder Engagement in Agricultural Conservation: Lessons from Saginaw Bay.**

The Saginaw Bay Watershed is Michigan's largest and faces a variety of water quality concerns including nutrient enrichment, altered hydrology and algal blooms. The Nature Conservancy has been working towards improving water quality and enhancing biodiversity within the Saginaw Bay Watershed for over a decade and is just one of many conservation stakeholders in the region. The Conservancy's work is unique in that they are striving to engage new partners, including agribusinesses and corporations, to develop innovative strategies to implement outcome-based conservation. These new strategies involve meaningful conservation goals based on science, online decision tools to target practices to specific fields, performance-based incentives and recruiting farmers via the agricultural supply chain. This presentation will briefly describe the innovative aspects of The Conservancy's projects but will primarily focus on 1) types of engagement strategies employed, 2) preliminary results of a comprehensive social evaluation conducted by the Natural Resources Social Science Lab at Purdue University, 3) lessons learned from The Conservancy's experience working with a multitude of partners, including agribusinesses, corporations and farmers, and 4) recommendations that might be transferrable to other Great Lakes watersheds. *Keywords: Saginaw Bay, Partnerships, Agriculture.*

FARESE, N., FUTIA, M., and RINCHARD, J., The College at Brockport - State University of New York, 350 New Campus Drive, Brockport, NY, 14420, USA. **Thiamine concentrations in forage fish from the Great Lakes region.**

Currently, salmonines in the Great Lakes region are experiencing abnormal behaviors and elevated offspring mortality due to Thiamine Deficiency Complex (TDC). The cause of TDC is unknown, but it has been linked to high consumption rates of Alewife. Alewife contain bacteria in their gut that produces thiaminase, a thiamine-degrading enzyme; however, recent studies have shown that thiaminase production is not high enough to cause TDC. In the Baltic Sea, a negative correlation between lipid content and thiamine concentration in forage fish has been shown. In the current study, forage fish (Alewife, Round Goby, and Rainbow Smelt) were collected from Lakes Erie, Michigan, and Ontario and Cayuga Lake to compare lipid content and thiamine concentration for each species. Preliminary results from Lake Ontario show that Alewife have the lowest total thiamine concentration (2.9 ± 2.3 nmol/g), while Round Goby had the highest concentration (8.0 ± 4.2 nmol/g). Thiamine derivatives (pyrophosphate, monophosphate, and free thiamine) varied by species as well. Thiamine pyrophosphate was the dominant vitamer in Rainbow Smelt and Round Goby (65% and 69%, respectively), whereas free thiamine was the most abundant in Alewife (55%). Lipid content will be determined for each species and correlations with thiamine concentrations will be evaluated. *Keywords: Thiamine Deficiency Complex, Vitamin B, Lipid Content.*

FARROW, C.R. and ACKERMAN, J.D., University of Guelph, Guelph, ON, CANADA. **Effects of river inputs on Phytoplankton Community Structure.**

Agriculturally-sourced nutrients from the Nottawasaga River have evoked concerns of the eutrophication of Southeastern Georgian Bay. We investigated the effect of phosphorus loading from the Nottawasaga River on near-shore Georgian Bay phytoplankton community structure using water sampled along a transect of the embayment. We used imaging flow cytometry (FlowCAM) to quantify algal taxa (~ 50 usually genera) using custom statistical filters in water samples collected on twelve cruises from mid-May to early-November 2016. Algal abundances were different among sampling stations and dates revealing successional changes among taxa in lake stations. For example, chrysophytes [*Dinobryon*, *Uroglena*, and *Synura*] dominated in spring and early-summer versus small-celled mucilaginous cyanobacteria [*Woronichinia*, *Merismopedia*, *Aphanothece*, and *Aphanocapsa*] in the late summer and fall. Chlorophytes and diatoms were more abundant in stations influenced by the river. A redundancy analysis of indicator taxa abundances based on physical and chemical data (including nutrients) will provide information on the major drivers of algal taxa abundances. This information will be used to determine whether and how the Nottawasaga River loading affects SE Georgian Bay algal community structure.
Keywords: Phytoplankton, Indicators, Nutrients.

FAUST, M.D.[1], VANDERGOOT, C.S.[2], BINDER, T.R.[3], HINDERER, J.L.M.[4], IVES, J.T.[4], HOSTNIK, E.T.[5], and KRUEGER, C.C.[6], [1]Ohio Department of Natural Resources, Division of Wildlife, Sandusky Fisheries Research Station, 305 East Shoreline Dr., Sandusky, OH, 44870, USA; [2]United States Geological Service, Great Lakes Science Center, Lake Erie Biological Station, 6100 Columbus Ave., Sandusky, OH, 44870, USA; [3]Michigan State University, Hammond Bay Biological Station, 11188 Ray Rd., Millersburg, MI, 49759, USA; [4]Great Lakes Fishery Commission, 2100 Commonwealth Blvd., Suite 100, Ann Arbor, MI, 48105, USA; [5]The Ohio State University, Department of Veterinary Clinical Sciences, 601 Vernon Tharp Street, Columbus, OH, 43210, USA; [6]Michigan State University, Center for Systems Integration and Sustainability, 1405 S. Harrison Rd., East Lansing, MI, 48823, USA. **Feasibility of Electrosedation as an Alternative to Chemical Sedation of Lake Trout.**

Use of electronic transmitters to inform lake trout restoration and suppression efforts is becoming increasingly common and such studies typically require fish sedation for

surgical implantation of transmitters in the coelom. Given that no immediate-release chemical sedative currently exists in North America, we investigated the feasibility of using electricity to sedate lake trout long enough for an experienced surgeon to implant an electronic transmitter (i.e., 180 s). Our study objectives were to 1) determine whether some combination of electrical waveform characteristics (i.e., duty cycle, frequency, voltage, and pulse type) could sedate lake trout for at least 180 s, and 2) determine if lake trout sequentially exposed to two different waveforms (i.e., continuous and pulsed direct current) had greater rates of spinal injuries and short-term (i.e., < 30 day) mortality than control fish. A two-stage approach using direct current followed by pulsed direct current effectively sedated lake trout for 180 s and did not show significantly different survival rates or spinal abnormalities than control fish. We suggest that the settings used here may be used for conducting surgeries to implant electronic transmitters in lake trout for future research studies, but note that morphotype-specific electrical waveforms should be explored.
Keywords: Fish tagging, Lake trout, Fish management.

FAUST, S.J., St. Clair County Health Department, 3415 28th Street, Port Huron, MI, 48060, USA. **Fish and Wildlife Habitat Restoration for the St. Clair River.**

The St. Clair River has undergone dramatic changes over the last century from shipping, industry and development. This has resulted in the loss of both habitat and species, especially spawning and feeding sites for fish and wildlife. This 44-mile stretch of river is an important corridor for movement of fish and wildlife, including some rare and sensitive species. The St. Clair River Fish and Wildlife Habitat Beneficial Use Impairment Plan prioritized restoration of three areas for the best ecological gain: in-river habitat, near shore habitat, and tributaries. Recent successful completion of ten habitat projects signifies that the Fish and Wildlife Beneficial Use Impairment can be restored. The St. Clair County Health Department is uniquely positioned to lead the habitat management and community outreach for these projects. Managing these, plus public perception and volunteers, are keys to a habitat project's long-term success. This presentation will share lessons learned and success stories of maintenance, public engagement and other best management practices that allow the success of habitat restoration projects to be carried into the future.
Keywords: Environmental health, St. Clair River, Habitats, Management, Public education, Watersheds.

FAZEKAS, H.M., KATONA, L.R., and VADEBONCOEUR, Y., Wright State University, 3640 Colonel Glenn Hwy, Dayton, OH, USA. **Attached Algae as Indicators of Stream Ecosystem Function in Headwaters of the Lake Erie Watershed.**

Headwater streams in the Lake Erie watershed in Ohio drain row crop agriculture, are deeply incised and most lack woody riparian vegetation. These attributes promote the growth of attached algae which can regulate the transport of nutrients downstream, determine oxygen dynamics, and provide an integrative index of nutrient stress. In November 2016, we conducted a survey of attached algal communities in headwater streams in the Maumee, Portage, and Grand River watersheds. Most sites in the Maumee and Portage River tributaries were immediately adjacent to row crop agriculture while the Grand River sites had varied adjacent land uses. The total mass of sediment and algae was highest in the Grand River tributaries and lowest in the Portage River. The phosphorus content of the algae (%P) was lowest in the Grand River tributaries and highest in the Maumee River tributaries. In all watersheds, sites that lacked woody riparian vegetation had high chlorophyll and sediment content relative to wooded sites. Furthermore, sites with grass riparian zones had higher temperature and oxygen concentrations than wooded sites, suggesting that attached algal photosynthesis was robust late in the season. We will discuss the efficacy of combining algal biomass, stoichiometry and enzyme activity to assess nutrient limitation in Lake Erie tributaries. *Keywords: Biofilm, Agriculture, Nutrients, Headwaters, Watersheds.*

FEISTHAUER, N.C., LAAMRANI, A., and JOOSSE, P.J., Agriculture and Agri-Food Canada, 174 Stone Road West, Guelph, ON, N1R 5S2, CANADA. **Assessing Vulnerability of Lake Erie Landscapes to Soil Erosion: Modelled and Measured Approaches.**

Loss of soil from agricultural landscapes to Lake Erie via water erosion is a key transport mechanism for phosphorus bound to soil particles. Agriculture is the dominant land use in the Canadian side of the Lake Erie basin with approximately 75% of the 2.3 million hectares under crop or livestock production. The variable geography and diversity of agricultural production systems and management practices makes estimating risk of soil erosion from agricultural landscapes in the Canadian Lake Erie basin challenging. Risk of soil erosion depends on a combination of factors including the extent to which soil remains bare, which differs with crop type and management. Two different approaches of estimating the vulnerability of landscapes to soil erosion will be compared among subwatersheds in the Lake Erie basin: a modelling approach incorporating farm census and soil survey data, represented by the 2016 Agriculture and Agri-Food Canada Agri-Environmental Indicator for Soil Erosion Risk; and, a measured approach using remotely sensed data that quantifies the magnitude of bare and covered soil across the basin. Results from both approaches will be compared by scaling the national level (1:1 million) Soil Erosion Risk Indicator and the remotely sensed data (30x30 m resolution) to the quaternary watershed level.
Keywords: Phosphorus, Lake Erie, Nutrients.

FENDLER, T.E.[1], FISK, A.T.[1], PITCHER, T.E.[1], PETTITT-WADE, H.[1], KESSEL, S.T.[2], CHIOTTI, J.A.[3], GORSKY, D.[4], and HONDORP, D.W.[2], [1]Great Lakes Institute for Environmental Research, University of Windsor, Windsor, ON, N9B3P4, CANADA; [2]Great Lakes Science Center, U.S. Geological Survey, Ann Arbor, MI, 41805, USA; [3]Alpena Fish and Wildlife Conservation Office, U.S. Fish and Wildlife Service, Alpena, MI, 49707, USA; [4]Lower Great Lakes Fish and Wildlife Conservation Office, U.S Fish and Wildlife Service, Basom, NY, 14013, USA. **Trophic Ecology of Adult Lake Sturgeon Movement Groups in the Huron-Erie Corridor.**

Foraging and habitat use are tightly linked aspects of ecology that should be considered together to inform conservation and restoration efforts of threatened species like the lake sturgeon (*Acipenser fulvescens*). We hypothesize that isotopic niches will vary between adult sturgeon that show broad scale migratory behaviours and those that are residents within river systems. Acoustic telemetry in combination with stable isotopes were used to assess the isotopic niches of adult lake sturgeon in the Huron-Erie-Corridor (HEC). Acoustic telemetry was used to establish the movement patterns of lake sturgeon, identifying individuals that made large scale movement (i.e., migration) and those that did not (i.e., resident). Initial results for lake sturgeon from the Detroit River show that migratory individuals have a higher trophic level, smaller isotopic niche size, and little isotopic niche overlap when compared to resident individuals, suggesting an increased diet dependency on fish. In the St. Clair River, migratory individuals had a larger isotopic niche than resident individuals and an increased dependence on pelagic primary production source based on lower $\delta^{13}C$. This unique combination of movement and stable isotope analyses provides novel insights on the feeding and spatial ecology of lake sturgeon. *Keywords: Niches, Lake Sturgeon, Stable isotopes.*

FERMANICH, K.J.[1], BAUMGART, P.[1], COOK, C.[2], KLUMP, J.V.[3], VERHAMME, E.M.[4], RUCINSKI, D.[4], LABUHN, S.[3], and HEIM, A.[1], [1]University of Wisconsin Green Bay, 2420 Nicolet Drive, Green Bay, WI, 54311, USA; [2]University of Wisconsin Extension, 625 E. County Road Y, Suite 600, Oshkosh, WI, 54901, USA; [3]School of Freshwater Sciences/UWM, 600 E Greenfield Ave, Milwaukee, WI, 53204, USA; [4]LimnoTech, 501 Avis Drive, Ann Arbor, MI, 48108, USA. **How will (could?) changes in farmland management systems shape Green Bay water quality?**

The health of the Green Bay ecosystem is strongly influenced by farm management within the basin. Along with weather events, cropland management actions largely dictate nutrient and sediment export to the Fox River and these exports are a primary driver of eutrophication and hypoxia in the bay. Our team developed watershed models for the Fox-Wolf River basin and simulated a selection of alternative farmland management actions. For

example, targeted reductions of soil P, in combination with conservation tillage and cover crops, resulted in a 27% reduction in runoff P export to the bay. The impacts of the alternative actions on Green Bay water quality response were assessed with a linked biogeochemical model. Through workshops, surveys, webinars, and a management analysis tool (MAT), managers informed selection of alternative scenarios and gained knowledge and experience with model results. Although these project outputs provided new understanding of the linkages between watershed inputs and Green Bay ecosystem response, the translation of complex model outputs to management actions has not been fully realized. Needed next steps include making scenario results more accessible (online MAT), more hands-on outreach, and refinement of modeling and analysis efforts to meet manager needs (e.g., economic tradeoffs, field level actions). *Keywords: Management, Modeling, Water quality.*

FERRIER, E.[1], BRAUN, H.[1], and KOWALSKI, K.[2], [1]Great Lakes Commission, S. Industrial Hwy, Ann Arbor, MI, 48104, USA; [2]US Geological Survey - Great Lakes Science Center, 1451 Green Rd,, Ann Arbor, MI, 48105, USA. **Developing a collaborative regional approach to Phragmites management, research, and restoration.**

Invasive Phragmites australis is a large-scale problem that requires a cooperative regional approach to manage. The Great Lakes Phragmites Collaborative (GLPC) is a joint effort by the US Geological Survey and the Great Lakes Commission as well as members from multiple agencies and organizations. The GLPC is structured and guided by the framework of Collective Impact. Under this framework, the Great Lakes Commission acts as a backbone organization to coordinate partners with diverse interests. Leadership committees and a Charter have been developed, and members are now building a mutually agreed-upon Common Agenda. The GLPC has developed centralized communication materials; reduced redundancy and streamlined information transfer; provided a research forum; created linkages between science and management; facilitated connections between actors across the region; encouraged site prioritization to maximize the benefits of control work; and supported restoration of wetland and terrestrial sites following Phragmites control efforts. We present the GLPC as a model for conservation or natural resource organizations to improve coordination and collaboration; facilitate adaptive, learning-based decision-making; create positive impacts for natural resource communities; and facilitate restoration of coastal and terrestrial habitats. *Keywords: Phragmites australis, Collective impact, Exotic species, Collaboration, Regional analysis.*

FIETSCH, C.L.[1] and ROSE, G.R.T.[2], [1]Bruce Power, 177 Tie Road, Tiverton, ON, N0G 2T0, CANADA; [2]Golder Associates Ltd., 6925 Century Ave, Mississauga, ON, L5N 7K2,

CANADA. **Case Study: Risk Assessment of Industrial Thermal Effluent on Fish Species of Interest.**

Bruce Power has monitored the thermal effects of Condenser Cooling Water (CCW) discharges into the Lake Huron environment for more than 40 years. This includes summer and winter monitoring. Measured temperatures are analyzed at hourly and daily intervals to understand the observed and range of temperatures seen in the immediate vicinity of the site. Temperatures are compared to literature thresholds for fish species of interest. Summer intake temperatures average 15°C and the increase in temperature after passing through the condensers averages 9°C; currents flow predominantly north (63%). Areal extents of the discharges are delineated to a 1°C change from ambient. Minimal cross connection is observed between discharges and intakes. Interaction with neighbouring Baie du Dore is also minimal. Lake and Round Whitefish embryos incubate in the nearshore during the winter and are thermally sensitive (Scott & Crossman, 1998). There is minimal effect on Lake or Round Whitefish survival with temperature fluctuations measured in the immediate vicinity of a nuclear generating station. Winter temperatures were measured at 28 locations, with 5 nearshore locations having a daily range of 6-8°C max and 4°C avg and all other locations (82%) exhibiting a daily range of 3-5.5°C max and 3°C avg. *Keywords: Lake Huron, Thermal effluent, Fish, Decision making.*

FISCH, N.C.[1], BENCE, J.R.[1], TRUESDELL, S.B.[1], CLARK, R.[1], MYERS, J.T.[2], and YULE, D.L.[3], [1]Quantitative Fisheries Center, Department of Fisheries and Wildlife, Michigan State University, East Lansing, MI, 48824, USA; [2]U.S. Fish and Wildlife Service, Ashland Fish and Wildlife Conservation Office, 2800 Lake Shore Dr. East, Ashland, WI, 54806, USA; [3]U.S. Geological Survey, Lake Superior Biological Station, 2800 Lake Shore Dr. East, Ashland, WI, 54806, USA. **A sex-specific, integrated statistical catch at age model applied to Cisco in Thunder Bay, Ontario.**

Cisco, *Coregonus artedi*, stocks in western Lake Superior declined greatly in the second half of the 20th century. Their ecological and commercial importance in this region has raised concern over the long-term maintenance of the fishery and health of the ecosystem. Current assessment strategies rely on hydroacoustic estimates of spawning stock biomass to set quotas. In an effort to develop a more robust assessment framework, we fit a sex-specific, integrated statistical catch at age model to Cisco in Thunder Bay, Ontario. The model utilized multiple sources of data including hydroacoustic estimates of spawning stock, harvest data, and commercial and fishery independent age compositions. Results suggest that the level of exploitation is modest to light in Thunder Bay. Where in the range of plausible abundances this stock is estimated to be depends on assumptions regarding whether hydroacoustic surveys provide an absolute measure of abundance and on assumptions

regarding natural mortality. We will discuss our work aimed at solving this issue, in addition to the possibility of addressing this problem and others within a size-structured model.
Keywords: Assessments, Stock assessment, Management, Cisco, Hydroacoustics, Population dynamics.

FISCHER, J.L.[1], WILLS, T.C.[2], ROSEMAN, E.[3], KENNEDY, G.[3], WILLIAMS, N.A.[3], and MAYER, C.M.[1], [1]University of Toledo, Toledo, OH, USA; [2]Michigan Department of Natural Resources, Harrison Township, MI, USA; [3]US Geological Survey, Great Lakes Science Center, Ann Arbor, MI, USA. **Physical Maturation of Artificial Reefs in the St. Clair-Detroit River System.**

Artificial reefs have been used to restore lake sturgeon (Acipenser fulvescens) spawning substrates in the St. Clair-Detroit River System. Early projects focused on biological metrics (e.g., proximity to historic spawning locations and staging adults) to guide reef placement. Although lake sturgeon spawned over constructed reefs, some reefs were buried by fine sediment which fills the interstitial spaces needed by developing eggs. Therefore, placement of more recent projects has also been guided by geomorphological criteria, identifying depositional zones and sediment sources. To evaluate the effectiveness of the revised placement process, we quantified physical maturation of artificial reefs using side-scan and down-looking sonar and underwater video surveys. Sonar allows quick surveys of large areas. It provides a hardness index to quantitatively track changes in reef hardness and infilling of fine sediments. We added underwater video to quantify sediment sizes and estimate percent infilling of artificial reefs. Initial assessments indicate that projects placed using geomorphological placement criteria remain similar in hardness indices, sediment size, and percent infilling one year after construction. Therefore, geomorphological placement criteria are a promising tool for improved reef restoration projects in large rivers.
Keywords: Detroit River, Cameras, St. Clair River, Restoration, Sediments.

FITZPATRICK, L.E.[1], FUJISAKI-MANOME, A.[1], GRONEWOLD, A.D.[2], ANDERSON, E.J.[2], SPENCE, C.[5], CHEN, J.[4], SHAO, C.[4], POSSELT, D.[3], WRIGHT, D.[3], LOFGREN, B.M.[2], and SCHWAB, D.J.[3], [1]Cooperative Institute for Limnology and Environmental Research, Ann Arbor, MI, USA; [2]Great Lakes Environmental Research Laboratory, Ann Arbor, MI, USA; [3]University of Michigan, Ann Arbor, MI, USA; [4]Michigan State University, East Lansing, MI, USA; [5]Environment Climate Change Canada, Gatineau, QC, CANADA. **Reconstructing evaporation over Lake Erie during the historic November 2014 lake effect snow event.**

The extreme North American winter storm of November 2014 triggered a record lake effect snowfall (LES) event in southwest New York. This study examined the evaporation from Lake Erie during the record LES event between November 17th-20th,

2014, by reconstructing heat fluxes and evaporation rates over Lake Erie using the unstructured grid, Finite-Volume Community Ocean Model (FVCOM). Nine different model runs were conducted using combinations of three different flux algorithms and three different meteorological forcings. A few non-FVCOM model outputs were also included for further evaporation analysis. Model-simulated water temperature and meteorological forcing data were validated with buoy data at three locations in Lake Erie. The simulated sensible and latent heat fluxes were validated with the eddy covariance measurements at two offshore sites. The evaluation showed a significant increase in heat fluxes over three days, with the peak on the 18th of November. Snow water equivalent data from NOAA's NOHRSC showed a spike in water content on the November 20th. The ensemble runs presented a variation in spatial pattern of evaporation, lake-wide average evaporation, and resulting cooling of the lake, however, the overall analysis showed significant evaporation from Lake Erie appeared to be the main contribution to the LES event. *Keywords: Lake effect snow, Atmosphere-lake interaction, Heat fluxes.*

FITZPATRICK, M.A., MUNAWAR, M., and NIBLOCK, H., Fisheries & Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7S 1A1, CANADA. **Eutrophication in Canadian Areas of Concern: A Comparative Assessment of Phytoplankton Dynamics.**

In Canada, a total of 6 Areas of Concern are currently designated as impaired under the criterion of "Eutrophication or Undesirable Algae". Fisheries & Oceans Canada has undertaken comprehensive surveys at 3 of these sites - the Bay of Quinte, Hamilton Harbour and Toronto Harbour - including phytoplankton biomass and taxonomic composition, primary productivity (C14), as well as nutrients and chlorophyll *a*. In the Bay of Quinte, summer phytoplankton biomass typically ranges from 2-6 g/m^3 with blooms (biomass > 3 g/m^3) of Diatomeae (*Aulacoseira*) and Cyanophyta (*Dolichospermum*) being common. In Hamilton Harbour, summer biomass was similar although blooms included Cryptophyceae (*Cryptomonas*), Cyanophyta (*Woronichinia*) and Dinophyceae (*Ceratium*). By contrast, the biomass in Toronto Harbour was considerably less (≈1 g/m^3) and assemblages were composed of Dinophyceae (*Peridinium*) and Cryptophyceae (*Cryptomonas, Rhodomonas*). Our goal is to compare and contrast the algal assemblages and dynamics in these eutrophic AoCs in order to develop a robust classification. This will in turn provide guidance as to what constitutes a Beneficial Use Impairment with a view towards the establishment of de-listing criteria. *Keywords: Algae, Ecosystem health, Phosphorus, Photosynthesis, Remediation.*

FLOOD, B.[1], WELLS, M.G.[1], YOUNG, J.[2], DUNLOP, E.[3], and HOWELL, T.[2], [1]University of Toronto Scarborough, 1265 military Trail, Toronto, ON, M1C1A4, CANADA; [2]Ontario Ministry of the Environment and Climate Change, 125 Resources Road, Toronto, ON, M9P

3V6, CANADA; [3]Ontario Ministry of Natural Resources and Forestry, 300 Water St, Peterborough, ON, K9J 3C7, CANADA; [4]Ontario Ministry of Natural Resources and Forestry, 300 Water St, Peterborough, ON, K9J 3C7, CANADA. **Analysis of barotropic and baroclinic flushing process in two large Great Lakes embayments.**

Persistent late summer dissolved oxygen minima in Kempenfelt Bay, Lake Simcoe and sporadic fish die-off in aquaculture farms in Parry Sound, Georgian Bay have motivated us to investigate the physical phenomena controlling the exchange of water between the embayments and main basins, which have a strong influence on water quality. Parry Sound (surface area ~ 92 km^2, Vol ~ 3.8 x 10^9 m^3) and Kempenfelt Bay (surface area ~ 34 km^2, Vol ~ 6.8 x 10^8 m^3) are comparable in size, but have vastly different geometries giving rise to distinct fluid dynamics. Using thermistor chain and ADCP field data from 2015 and 2016, we will present a quantitative analysis and comparison of the dominant flushing mechanisms in the two embayments, along with estimates of their respective flushing rates. Preliminary results indicate that despite significantly different internal wave dynamics, internal waves (baroclinic forces) are up to ten times more effective at flushing than surface waves (barotropic) at both sites. These results will be useful in developing accurate water quality models and understanding the temporal and spatial variation of fish habitat for the aquaculture industries in Parry Sound and fish monitoring programs in both study sites.
Keywords: Georgian Bay, Lake Simcoe, Water currents.

<u>FLOREY, C.L.</u> and MARTIN, A.L., Saginaw Valley State University, University Center, MI, 48710, USA. **Effects of Bupropion, an Environmental Contaminant, on a Keystone Aquatic Species.**

Bupropion is an atypical antidepressant commonly prescribed in human medicine for the treatment of clinical depression and other mood disorders. Bupropion present in wastewater and hospital effluent has been shown to affect prey behavior of fish, reduce distress in rats, and increase aggression in mice. In order to further examine the effects of this chemical, this study quantified aggression of crayfish (*Orconectes rusticus*), a keystone species invasive to the Great Lakes Region, when exposed to environmentally relevant concentrations. Crayfish were exposed to varying concentrations (0, 25, 50, 100, and 200 ng/L) of bupropion for 48 hours. Effects of agonistic interactions were examined with 12 aggression trials for each exposure level (2 crayfish per trial). The pair acclimated to opposite sides of a divided tank for 10 minutes; the divider was them removed and the crayfish were allowed to interact for 15 minutes. Agonistic encounters were quantified using a modified ethogram to score intensity of aggressive interactions and determine encounters' winners and losers. Data was analyzed with ANOVAs to demonstrate the effects of bupropion on an aquatic invertebrate. The effects that bupropion have on crayfish behavior could negatively impact its role as a keystone species in aquatic ecosystems in the Great Lakes Region. *Keywords: Invasive species, Pollutants, Crustaceans.*

FOLEY, C.J.[1], BEUGLY, J.S.[1], and KNOWLES, E.[2], [1]Purdue University Department of Forestry and Natural Resources, West Lafayette, IN, 47907, USA; [2]Illinois-Indiana Sea Grant, Urbana, IL, 61801, USA. **Birth and success of the @TwoYellowBuoys Twitter account.**

Illinois-Indiana Sea Grant (IISG) owns and maintains two real-time monitoring buoys that are deployed annually in nearshore Lake Michigan. In 2015, IISG specialists began manning the @TwoYellowBuoys Twitter account. Written from the perspective of the buoys themselves, this account has proved a popular way to share data patterns and buoy-related news with interested stakeholders. In this presentation, IISG specialists will describe some of the more successful strategies they have employed, examine how they are able to determine "impact" from Twitter interactions, and show a lot of images of Lake Michigan data. *Keywords: Buoys, Lake Michigan, Observing systems.*

FOOSE, M.[1] and ELLISON, R.[2], [1]Michigan Office of the Great Lakes - Department of Environmental Quality, 27700 Donald Court, Warren, MI, 48092, USA; [2]US Enivronmental Protection Agency, 9311 Groh Road, Gross Ile, MI, 48138, USA. **St. Clair River AOC Habitat Restoration Sites.**

This presentation is a case study of the St. Clair River Area of Concern (AOC) habitat restoration projects conducted under the GLRI from 2010 - present. In December 2015, USEPA completed dredging operations at the Krispin Drain Habitat Restoration site on Harsens Island in the St. Clair River and MDEQ completed the restoration of Cuttle Creek in Marysville, MI, to complete the last of the target habitat restoration projects that were required to address the Loss of Fish and Wildlife Habitat Beneficial Use Impairment in the St. Clair River. The St. Clair River is an Area of Concern under the Great Lakes Water Quality Agreement. Starting with the first year of GLRI funding in 2010, numerous federal, state, local and non-profit organizations have completed a total of ten projects in twelve locations throughout the St. Clair River. These restoration projects included the construction of three spawning reefs resulting in seven acres of new fish spawning habitat in the St. Clair River and delta; two tributary and delta projects resulting in over 3.5 miles of tributary and delta habitat; and seven projects totaling 1.5 miles of river shoreline restoration, the creation of five acres of wetland and 15.5 acres of riparian habitat. *Keywords: Habitats, St. Clair River.*

FORD, R.T. and VODACEK, A., Chester F. Carlson Center for Imaging Science, Rochester Institute of Technology, 54 Lomb Memorial Drive, Rochester, NY, 14623, USA. **Quantifying Landsat's Ability to Monitoring Cyanobacteria in the Great Lakes Region.**

In 2016 an algal bloom in Owasco Lake lead to the detection of toxins attributable to cyanobacteria within the treated drinking water of its surrounding communities, a first for any of the Finger Lakes. The same year, five other Finger Lakes had blooms of varying intensity. Blooms in these smaller waterbodies demonstrate the need for higher spatial resolution imaging systems for monitoring cyanobacteria. Landsat 8, with its 30-meter spatial resolution, was used to quantify the concentrations of chlorophyll-a and phycocyanin in Honeoye and Owasco Lake. The concentrations of these pigments were retrieved using Look-up-Tables generated with the Hydrolight modeling software. The accuracy of these retrievals was compared against in-situ measurements collected within 24 hours of the satellite overpass. Simulations were also run to determine how future changes to the Landsat sensors could affect their accuracy in quantifying blooms. These changes include varying spectral coverage, and improving radiometric resolution and system noise. These tests show how future Landsat missions can be designed to better monitor cyanobacteria blooms.
Keywords: Remote sensing, Landsat, Harmful algal blooms, Cyanophyta.

FORMBY, T.A.[1], LOVALL, S.B.[2], and DRAUS, P.[3], [1]Marathon Petroleum Company LP, 1001 S. Oakwood Ave, Detroit, MI, 48217, USA; [2]PEA, Inc., 7927 Nemco Way, Brighton, MI, 48116, USA; [3]University of Michigan Dearborn, 4901 Evergreen Rd, Dearborn, MI, 48128, USA. **A Greenspace Vision in Southeast Michigan's Most Heavily Industrialized Area.**

The Rouge River gateway corridor is one of the most important natural and cultural assets of southeast Michigan. This presentation addresses how a greenspace vision can mitigate environmental degradation near the Rouge River's Fort Street crossing. In 2011, Marathon Petroleum Company LP initiated a voluntary property purchase program in the Oakwood Heights Neighborhood. Blighted homes were removed, and the grounds were restored with the intent of further environmental enhancement over time. Revitalizing the area, celebrating heritage, preserving natural Great Lake habitats and supporting recreational opportunities evolved as vision priorities. Integral to the project is a small park proposed by community stakeholders to memorialize the 1932 Hunger March, when neighborhood residents organized on the Fort Street Bridge before walking to the Ford Rouge Plant to negotiate better working conditions. Meeting resistance, five people were killed. Panel participants will discuss how private industry can work with NGOs and public agencies to transform blighted areas. Oakwood Heights is slated to become a wildlife "hub" supporting interconnected green infrastructure along the Rouge and Detroit Rivers - a new, living connection between Detroit and downriver communities. *Keywords: Community involvement, Economic impact, Rouge River, Habitats, Ecosystem health.*

FOUBISTER, D.D., WHITE, C.J., and WILKIE, M.P., Wilfrid Laurier University, Waterloo, ON, CANADA. **Effects of Sampling Techniques on Forensic Markers of Lampricide Mortality in Non-Target Fishes.**

The lampricides 3-trifluoromethyl-4-nitrophenol (TFM) and niclosamide are applied to tributaries of the Great Lakes to control parasitic sea lampreys *(Petromyzon marinus)*. Although TFM is selectively toxic to larval sea lampreys, on occasion lampricides can cause non-target mortality. It is therefore important to determine if lampricides play a role in instances where unexpected fish kills take place. Using forensic approaches, the goal of my work is to determine which tissues, handling, and storage techniques are best suited for measuring post-mortem lampricide and metabolite concentrations in the non-target fishes, rainbow trout *(Oncorhynchus mykiss)*, and white sucker *(Catostomus commersonii)* exposed to lethal concentrations of these pesticides. Experiments indicated that rainbow trout had a 12-h LC50 of 14.62 mg/L, compared to a value of 15.07 mg/L TFM in white sucker. Measurements of tissue TFM and its metabolites are presently underway to establish the internal concentrations of TFM that cause death. Follow-up measurements also include determining the effect that storage, freezing and thawing of blood and tissue samples has on the stability of the lampricides and their metabolites. This research will facilitate the development of sampling and shipping protocols for use by sea lamprey control agents. *Keywords: Fish, Piscicide, Great Lakes basin, Metabolites, Toxic substances, Forensics.*

FOURNIER, A.M.V., Arkansas Cooperative Fish and Wildlife Research Unit - University of Arkansas, 1 University Drive SCEN 632, Fayetteville, AR, 72701, USA. **#MORails #MOScience : Tweeting Live From The Field.**

The combination of field work and social media, in this case twitter, presents a fantastic opportunity to share your science with the general public as it is happening. I will share my experiences, successes, and failures of three years of tweeting about my doctoral work (#MORails) studying the autumn migration of rails in wetlands across Missouri. Through text, pictures and video I've been able to share my work, and teach people around the world about wetland processes, their importance in the larger ecosystem, and why rails are so incredibly cool. I'll provide tips for how to tweet about your own work, create a hashtag, find an audience, and share your science. *Keywords: Outreach, Birds, Wetlands.*

FOURNIER, A.M.V.[1], SHEILDCASTLE, M.C.[2], KASHMER, T.[2], and MYLECRAINE, K.A.[3], [1]Arkansas Cooperative Fish and Wildlife Research Unit - University of Arkansas, Fayetteville, AR, USA; [2]Black Swamp Bird Observatory, Oak Harbor, OH, USA; [3]New Jersey Audubon, Bernardsville, NJ, USA. **Comparison of Arrival Dates of Rail Migration in the Southwest Lake Erie Marshes, Ohio, USA.**

Several studies have documented the arrival time of spring migration of Virginia Rails (*Rallus limicola*), King Rails (*R. elegans*), and Soras (*Porzana carolina*) on the southwestern shore of Lake Erie, though not in recent decades, and most of this information is based on anecdotal records. These three species were captured in wetlands on Ottawa National Wildlife Refuge in Ottawa and Lucas Counties, Ohio, USA, from 2004 to 2009. Virginia Rails and Soras were documented arriving in northern Ohio earlier than previous research, but not older anecdotal records. King Rails were within the bounds of all previous records. Using traps with playback may have allowed us to detect these species at earlier dates than previous research. Documenting current spring migration arrival timing of these three secretive marsh bird species is important for future monitoring, research and wetland management. *Keywords: Avian ecology, Wetlands, Monitoring.*

FRALEY, E.F. and UZARSKI, D.G., Central Michigan University, Mount Pleasant, MI, 48858, USA. **The relationship between vegetation and ice formation in Great Lakes coastal wetlands.**

The floral zonation of Great Lakes coastal wetlands is determined by environmental stress and hydrology. While water level fluctuations are the primary influence, previous studies suggest that ice movement and formation may be a contributing factor. If ice does play a role, a climatic shift to more mild winters will impact the plant community structure. In this study we monitored six Great Lakes coastal wetlands on Saginaw Bay and the Southern Upper Peninsula of Michigan. Data were collected four times per year on fixed transects. Sampling in early and late winter revealed evidence of ice disturbance on the dead vegetation. In midwinter we collected ice depths and formations as well as used time lapse photography to capture ice movement. In summer, we monitored the vegetation for the percent cover of each plant species, total percent vegetation-cover and stem densities. We used univariate and multivariate statistical analyses to compare and correlate environmental data with vegetation characteristics. We found ice formation was correlated with vegetation type, most strongly with the presence of *Phragmites australis*. The reduction of ice depth in sites invaded by *P. australis* could reflect a higher fall water temperature facilitated by the dense, tall stands of this invasive plant. *Keywords: Coastal wetlands, Vegetation, Ice.*

FRANCOEUR, S.N., Eastern Michigan University, Ypsilanti, MI, 48197, USA. **Light Saturation and P Limitation of Saginaw Bay Charophycean Algae.**

Like many other benthic algae, Charophycean algae appear to be experiencing a resurgence within the Laurentian Great Lakes. Charophytes can attain high abundance in shallow waters, thereby affecting benthic ecology and nutrient cycling, and their subsequent death, detachment, and shoreline deposition contribute to beach fouling. In-situ nutrient enrichment experiments and stoichiometric analyses have shown that other types of Great Lakes benthic algae are frequently phosphorus (P)-limited, but comparable information is lacking for charophytes. This study coupled short-term P enrichment of charophytes collected from inner Saginaw Bay with fluorometric estimates of algal photosynthesis to assess potential nutrient limitation. Benthic irradiance at the experimental sites was frequently sufficient to saturate charophyte photosynthesis, and charophyte photosynthesis was frequently stimulated by experimental P enrichment, suggesting that these algae were P-limited under natural conditions. Reduction of P loading may be an effective charophyte control measure, even in relatively light-poor and nutrient-rich areas of the Great Lakes.
Keywords: Benthic flora, Algae, Nutrients.

FRANCY, D.S.[1], BRADY, A.M.G.[1], and HAYHURST, B.A.[2], [1]U.S. Geological Survey, 6460 Busch Blvd, Columbus, OH, 43229, USA; [2]U.S. Geological Survey, 30 Brown Road, Ithaca, NY, 14850, USA. **Statistical models for estimating levels of E. coli and microcystins in waters as management tools.**

Cyanobacterial harmful algal blooms and associated toxins, such as microcystin, and the presence of pathogenic microorganisms and E. coli cause public health concerns throughout the Great Lakes. Drinking-water treatment plant operators and beach managers need time-relevant information to make informed decisions on the levels of microcystin and E. coli in waters used by the public. Site-specific multiple-linear regression models that use quickly-measured environmental variables as surrogates for a contaminant are simple tools that can aide in management decisions and inform the public. The Ohio and New York Nowcasts provide real-time information on the probability of exceeding a threshold E. coli concentration based on models at 9 and 7 sites, respectively. This approach could be expanded to include models for estimating microcystin concentrations at recreational sites and in source waters for drinking-water plants. In a 2013-14 study, investigators identified factors significantly correlated to microcystin in environmental waters that could be used in models; these included phycocyanin, pH, streamflow, and cyanobacterial gene concentrations. Software tools for data management and model development, coordination and cooperation of multiple agencies, and training and oversight enable the use of models as management tools.

FRENCH, N.T., Minnesota Pollution Control Agency, 525 Lake Avenue S, Duluth, MN, 55614, USA. **Creative Financing: Implementing the St. Louis River Area of Concern Remedial Action Plan in MN.**

The St. Louis River Area of Concern (SLRAOC) is the second largest of the 43 Great Lakes Areas of Concern designated under the Great Lakes Water Quality Agreement in 1987. The most significant problems identified relate to the presence of legacy contaminants in sediments and physically altered fish and wildlife habitat. These impacts were found in the St. Louis River Estuary portion of the SLRAOC. The SLRAOC was required to develop a Remedial Action Plan to address specific identified problems known as beneficial use impairments using a systematic and comprehensive ecosystem approach that included substantial local stakeholder participation. Several early versions of the Remedial Action were developed and most recently, an updated plan was adopted in July 2013. This presentation will summarize actions taken over the past 30 years with a focus on the development and implementation of the bold and aggressive 2013 business plan and the creative financing approach taken. We will review the inclusive collaborative process by which priority actions were identified and the unique and timely identification of the financial resources required to implement the action items identified in the plan. We will also report on the status of Remedial Action Plan implementation and progress towards beneficial use impairment removal and delisting. *Keywords: St. Louis River AOC, Business Plan, Great Lakes Restoration Initiative (GLRI), Funding, Lake Superior.*

FRY, L.M.[1], GRONEWOLD, A.D.[2], BOLINGER, R.[3], and MUELLER, R.[4], [1]U.S. Army Corps of Engineers Detroit District Office of Great Lakes Hydraulics and Hydrology, Detroit, MI, USA; [2]National Oceanic and Atmospheric Administration Great Lakes Environmental Research Laboratory, Ann Arbor, MI, USA; [3]Colorado Climate Center, Fort Collins, CO, USA; [4]New York Power Authority, Marcy, NY, USA. **Assessment of Probabilistic 5-year Forecasts of Great Lakes Levels and Outflows for Hydropower.**

Operational forecasts of Great Lakes water levels and outflows have focused on near term, high resolution model output (e.g. NOAA's Great Lakes Coastal Forecasting System) or seasonal water level forecasts (i.e. the Coordinated Forecast of Great Lakes Water Levels published by USACE and ECCC). These forecasts have applications for shipping, regulation, and other users. However, decision-making in the hydropower industry takes place on timeframes out to several years, and independent, third-party water level forecasts going out 5 years could result in significant savings in the form of reduced insurance premiums. Ensemble forecasting systems that incorporate physical processes and reflect regulation decisions and lake-to-lake routing are a promising alternative to the statistical analyses used for such financial hedging. This presentation will describe and assess a new forecasting system developed through a collaboration among research, operational, and hydropower organizations that aims to meet this need for long-range probabilistic 5-year forecasts of Great Lakes water levels and connecting channel flows. *Keywords: Hydrologic budget, Computer models, Great Lakes basin.*

FUJISAKI-MANOME, A.[1], WANG, J.[2], and ANDERSON, E.J.[2], [1]University of Michigan, 2455 Hayward St., Ann Arbor, MI, 48109, USA; [2]NOAA Great Lakes Environmental Research Laboratory, 4840 S. State St., Ann Arbor, MI, 48108, USA. **Modeled ice thickness in Lake Erie with different parameterizations of the ice strength.**

An unstructured grid Finite-Volume Community Ocean Model (FVCOM) is applied to Lake Erie to simulate seasonal ice cover. The model is coupled with an unstructured-grid, finite-volume version of the Los Alamos Sea Ice Model. Given that there has been no solid formulation for the ice strength P for relatively thin ice in Lake Erie, a sensitivity study was conducted using the existing formulations of P. The probability density distribution of modeled ice thickness presented significant variability with the P parameterizations. The energy-based parameterization from Rothrock (1975) and Lipscomb et al. (2007) produced too thick ice, but this is not surprising as this parameterization was originally developed for thick ice in the Arctic Ocean where pressure ridges are more common, while thin ice and rafting would be more common in Lake Erie. Overall, the simple Hibler (1979)'s parameterization presented better agreement with the observed ice conditions. A better set of ice thickness observations is needed for a more rigorous formulation of P in Lake Erie and the four other Great Lakes. *Keywords: Model studies, Lake Erie, Ice.*

FUJIWARA, S., JFE Engineering Corporation, 2-1, Suehiro-cho, Tsurumi-ku,, Yokohama, KA, 230-8611, JAPAN. **JFE ballast water management system.**

JFE Engineering developed the ballast water management system, "System", which is comprised of filtration and two chemical agents, disinfectant and neutralizer. For practical application of the "System", JFE Engineering verified the treatment performance and assessed the environmental impact of the discharged water in a series of experiments from land-based tests to onboard tests. These tests were conducted in compliance with the guidelines established by the International Maritime Organization (IMO). The test results demonstrated that the "System" satisfies both treatment performance and safety requirements. The "System" received the approval from the IMO in 2010, Furthermore, in order to evaluate the system performance in fresh water, the scale of 200m3/h land-based status tests were carried out on the GSI land-based test site in Superior in accordance with the ETV protocol in 2014. The test results met discharge standards. Thus we could obtain amended certificates of the type approval from Japanese government and AMS certificate from USCG covering all salinities, not only marine and blackish water but also fresh water. We are currently testing for USCG type approval. *Keywords: Ballast, Water quality, Chemical analysis.*

FUTIA, M. and RINCHARD, J., The College at Brockport - State University of New York, 350 New Campus Drive, Brockport, NY, 14420, USA. **Comparison between diet and thiamine deficiency complex in wild Lake Ontario salmonines.**

Thiamine Deficiency Complex (TDC) is a dietary syndrome causing abnormal behaviors and ultimately death in salmonines. Thiamine is an essential vitamin and has been deficient in salmonines from the Great Lakes region since the 1960s, limiting recruitment in wild populations through high early life stage mortality. Thiamine deficiencies have been linked to the consumption of Alewife, which is a major prey fish in Lake Ontario. In the present study, thiamine concentrations and fatty acid signatures (FAS) were determined for Chinook Salmon, Coho Salmon, Brown Trout, Steelhead Trout, and Lake Trout collected from Lake Ontario during their 2015 spawning period. Thiamine was measured in egg, liver, and muscle tissue while FAS were determined from belly flap samples. Additional eggs were taken from each ovulating female and fertilized. Alevin development was observed and TDC-induced mortality was determined. Forage fish were collected for FAS analyses and will be compared with salmonine FAS to determine predator-prey relationships. Alevin mortality was highest in Steelhead Trout (87.0 ± 18.4%) followed by Coho Salmon (54.2 ± 24.7%), Lake Trout (33.8 ± 29.9%), and Chinook Salmon (17.1 ± 25.2%). Comparisons among thiamine concentrations, FAS, and TDC-induced offspring mortality will be discussed. *Keywords: Vitamin B, Thiamine Deficiency Complex, Lake Ontario, Salmon.*

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GAIBISELS, K.M.L. and SHARMA, S., York University, 4700 Keele Street, Toronto, ON, M3J 1P3, CANADA. **The effects of climate change on water level fluctuations in north temperate lakes.**

Bodies of fresh water are vital for human consumption, agriculture, recreation, fishing, and shipping. Our study investigates how water levels have changed over time in northern Wisconsin lakes, the drivers of these changes, and forecasts levels in 2050 and 2070 under scenarios of climate change. Between 1984-2014, the regional climate became 2.3°C warmer and precipitation decreased by 7.3mm, resulting in a decline of 6-120cm in water levels. Proportionally, 48.9%, 29.6%, and 22.4% of the variation in annual and seasonal water levels was explained by precipitation, temperature, and teleconnections indices respectively. On both the annual and seasonal scales, negative phases of the El Niño Southern Oscillation and the Pacific Decadal Oscillation, and positive phases of the Atlantic Multidecadal, Tropical Northern Hemisphere, Western Pacific, Sunspot Cycle, and the Polar Eurasian Oscillations were important drivers of lower water levels. Levels will have fallen by an average of 72cm from historical levels by the year 2050, and by 68cm by 2070, with climate projected to become warmer and wetter over the next century. Changes in water level could lead to an altered frequency of algal blooms, changes in water clarity, and shifts in the foraging and reproductive success of different fish species. *Keywords: Climate change, Modeling, Water level fluctuations.*

GARDNER COSTA, J.M.[1], CIBOROWSKI, J.J.H.[1], MCPHAIL, A.K.[2], MACKEY, S.D.[3], WANG, L.[1], LANDRY, J.[1], BOSTON, C.M.[4], MIDWOOD, J.D.[4], DOKA, S.E.[4], and SHERMAN, K.[2], [1]University of Windsor, 401 Sunset Ave., Windsor, ON, N9B 3P4, CANADA; [2]Severn Sound Environment Association, 67 Fourth St., Midland, ON, L4R 3S9, CANADA; [3]Habitat Solutions NA, Norwalk, OH, USA; [4]Fisheries and Oceans Canada, 867 Lakeshore Rd, Burlington, ON, L7S 1A1, CANADA. **Using Remote Sensing to Map and Classify the Condition of Nearshore Fish Habitat in Severn Sound, ON.**

Lake margins are especially sensitive to coastal alteration by humans, yet limited technology exists to survey these shallow waters that are important as fish habitat. We used a of combination sonar techniques (unmanned, boat-mounted, sidescan), to assess nearshore aquatic habitat in Severn Sound (SS), ON. Bathymetry, substrate texture, aquatic plant density, fetch and temperature data were collected in a stratified design throughout SS, a former Area of Concern. Data processed in the coastal areas of Penetang Harbour (part of SS) serve as a template for classifying habitat layers, creating habitat quality categories and eventually extrapolating quality for all of SS. Electrofishing data collected by Department of Fisheries and Oceans Canada will be superimposed on the habitat layers to model fish habitat suitability of the entire SS nearshore. Combined with a Digital Elevation Model derived from several sources of point elevation data (Ortho-photos and an interpreted shoreline), we simulated the changes in the amount and quality of SS fish habitat over time since a previous (1997) habitat quality survey. These data will provide science advice for fish management in SS, and serve as an approach for undertaking nearshore habitat assessment along coastal margins of other Great Lakes regions. *Keywords: Remote sensing, Nearshore, Habitats, Habitat Suitability, Lake Huron.*

GASSET, N. and FORTIN, V., Environment and Climate Change Canada, 2121 Transcanada Highway, Dorval, QC, H9P1J3, CANADA. **Towards a 30 years North American Precipitation and Land Surface Reanalysis.**

In support of the International Watersheds Initiative (IWI) of the International Joint Commission (IJC), a 30 years precipitation and land surface reanalysis covering North America at a 3 hours and 15 km resolution is currently being developed at the Canadian Meteorological Centre (CMC). A deterministic reforecast / dynamical downscaling approach is followed where a global reanalysis (ERA-interim) is used as initial condition of the Global Environmental Multi-scale model (GEM). The latter is coupled with precipitation and surface data assimilation systems, i.e. the Canadian Precipitation Analysis (CaPA) and the Canadian Land Data Assimilation System (CaLDAS). All systems used are closely related to model versions and configurations currently run operationally at CMC, meaning they have undergone a strict and thorough validation procedure. In this presentation, several configurations of the approach are evaluated for a couple of recent years (2013-2015) using both standard CMC validation methodology as well as more specialized scores. Preliminary results are very encouraging. A special attention is given to the Great Lakes Watershed area, where the value-added of such a reanalysis is demonstrated against the currently available products, notably for hydrological and hydrodynamic applications. *Keywords: Climatic data, Data assimilation, Atmospheric circulation, Watersheds.*

GASTEYER, S., Michigan State University, 509 E. Circle Drive, Berkey Hall #316, East Lansing, MI, 48824, USA. **Engaging Local Knowledge and Context: Farmers and Community Institutions in Watershed Management.**

Key to addressing the challenges of nutrient contribution to water quality impairment in the US Great Lakes is addressing the contribution of agriculture. This paper discusses the importance of engaging farmers in the process of minimizing nutrient runoff. Since the 1980s, a robust scholarly literature has developed on the importance of farmer-based crop and land management as a strategy to address water quality impairment. This paper will build on that literature, arguing for an approach that uses participatory research and engagement techniques pioneered in developing countries to engage farmers and farm-community residents in identification of solutions to nutrient runoff. Using as examples work done in the River Raisin watershed in Michigan, the presenter will describe the importance of recognizing, respecting, and valuing the local knowledge of farmers and community members, while simultaneously identifying new opportunities to support and incentivize action to protect water quality. The paper will conclude with recommendations for policy, research, and action. *Keywords: Watersheds, Participatory Research, Lake Erie, Farmer-Led Conservation, Conservation, Community Support Structures.*

GATES, O.C., JORNS, J., and ROOD, R., Great Lakes Integrated Sciences and Assessments Center, Ann Arbor, MI, 48104, USA. **The Great Lakes Adaptation Data Suite: Evaluating the Utility of a Data Suite for the Great Lakes.**

The climate of the Great Lakes region has been a topic of interest for researchers trying to understand its dynamics and significance to climate impacts in the region. The Great Lakes Adaptation Data Suite (GLADS) is a collection of over-land and over-lake observational and reanalysis data sets that span the Great Lakes basin. The GLADS provides users with standardized data aggregated to temporal and spatial resolutions suitable for comparisons and correlation analysis. Because these data sets are standardized, the need for gathering and processing the data is reduced for researchers. The evaluation of this data suite is vital for providing the most useful data, metadata, and guidance to end users and for understanding potential applications of this data. Currently in this evaluation phase, curators of the data suite will provide data guidance and assistance to users willing to provide feedback and suggestions pertaining to evaluation. Overall, the motivation is to better enable researchers and climate adaptation professionals to make decisions based on the findings that develop from this data suite. *Keywords: Climate change, Climatic data, Climatology.*

GEE, J.[1] and WALSH, D.[2], [1]Environment and Climate Change Canada, 4905 Dufferin Street, Toronto, ON, M3H 5T4, CANADA; [2]Ontario Ministry of Environment and Climate Change, 1259 Gardiners Rd, Kingston, ON, K7P 3J6, CANADA. **Restoring Canada's Great Lakes Areas of Concern- Progress and Lessons Learned.**

Canada, in partnership with Ontario and with extensive public consultation has developed and implemented Remedial Action Plans (RAPs) for all of the Canadian Areas of Concern (AOCs). Implementation of remedial actions is well underway in all AOCs and involves many sectors of society- including all levels of government (federal, provincial, municipal, and Indigenous communities), industry, non-government organizations and individuals. Significant progress has been made in restoring impaired beneficial uses and delisting Areas of Concern. Jon Gee and Dawn Walsh, the federal and provincial leads, respectively, for Areas of Concern under Annex 4 of the Canada-Ontario Agreement on Great Lakes Water Quality and Ecosystem Health will highlight the progress made in: 1) remediation of contaminated sediments; 2) restoration of fish and wildlife habitat; 3) municipal and industrial waste water treatment and non-point source management; and 4) beneficial use status assessments and follow-up monitoring. They will also share their insights on lessons learned and remaining challenges. *Keywords: Great Lakes basin, Areas of Concern, Watersheds, Management.*

GEISTHARDT, E.J.[1], JANSSEN, J.A.[1], and SUEDEL, B.[2], [1]University of Wisconsin-Milwaukee, 600 East Greenfield Ave, Milwaukee, WI, 53204, USA; [2]United States Army Corps of Engineers, 4155 Clay Street, Vicksburg, MS, 39183, USA. **A Novel Ecosystem at a Modified Boulder Breakwall.**

The US Army Corps of Engineers (ACE) is mandated to repair aging breakwalls in Great Lakes commercial ports. The Milwaukee Harbor ACE "Green" Breakwall created new rocky aquatic habitat by depositing cobble-sized stone as a veneer over standard 6-8 ton boulders, thus creating control (boulder) and treatment (cobble) habitats. The breakwall harbors a prolific population of Hemimysis anomala, the introduced Ponto-Caspian mysid, which is more abundant on cobble versus boulders ($p<0.05$, using a novel trap for Hemimysis). This nearshore lithophilic mysid provides a seasonal food resource in the Milwaukee Harbor for pelagic prey fishes during spawning migrations and upwelling events. Alewife and rainbow smelt fed heavily on Hemimysis with some individuals consuming hundreds of mysids. Night scuba diving surveys and gill netting confirmed that rainbow smelt preferred to forage on the cobble ($p<0.05$), and also consumed more Hemimysis there than they did at the control site ($p<0.05$). Hemimysis were also significant in the diets of YOY yellow perch, YOY largemouth bass, and juvenile rock bass at the MHGBW. We believe that the construction of the MHGBW has aided the productivity of this benthopelagic macroinvertebrate to create a novel ecosystem benefiting forage fish and creating nursery habitat for nearshore gamefish juveniles. *Keywords: Food chains, Hemimysis anomala, Lake Michigan, Macroinvertebrates.*

GEORGE, E.M., HARE, M.P., and RUDSTAM, L.G., Cornell University, 111 Fernow Hall, Ithaca, NY, 14850, USA. **Genetic Limitations to Cisco Restoration in Lake Ontario.**

Cisco *Coregonus artedi* are an important prey fish for many Great Lakes predators, including lake trout *Salvelinus namaycush*. Their numbers have declined in the last century due to overfishing, habitat degradation, and invasive species. Chaumont Bay, New York and the Bay of Quinte, Ontario contain the last two known spawning stocks of cisco in Lake Ontario. Our current project aims to assess the genetic diversity of the remnant spawning population in order to test for genetic bottleneck effects following historical population size reductions, determine the wild effective population size, compare the genetic status of the Chaumont and Quinte stocks, and identify potential cases of hybridization with lake whitefish *Coregonus clupeaformis*. Results from this project will give managers a better understanding of the population structure of the Lake Ontario stock, assist with future management decisions, and provide guidance for hatchery-based population supplementation efforts. *Keywords: Genetics, Coregonine, Lake Ontario, Fish populations.*

GERIG, B.S.[1], CULLEN, S.[1], CHALONER, D.T.[1], GREIL, R.[2], MOERKE, A.H.[2], and LAMBERTI, G.A.[1], [1]University of Notre Dame, 299 Galvin Science Center, Notre Dame, IN, 46556, USA; [2]Lake Superior State University, 650 W. Easterday Ave, Sault Ste. Marie, MI, 49783, USA. **Atlantic salmon in Great Lakes food webs: Implications for future stocking and pollutant monitoring.**

Salmonines are important components of the Great Lakes fishery. However, invasive species, especially Dreissenid mussels, have shifted energy flow and contaminant cycling from the pelagic to the benthic zone in Lake Huron. This altered food web structure is linked to population declines in Chinook salmon. Consequently, state management agencies have increased stocking of Atlantic salmon to maintain diversity in the recreational fishery. In this study, we used stable isotopes of carbon (δ13C) and nitrogen (δ15N), along with mercury (Hg) to compare food web position and bioaccumulation among Lake Huron salmonines, especially Atlantic salmon, compared with other species. When comparing isotopic niche space, Atlantic salmon exhibit significant overlap with both Chinook and coho salmon, suggesting reliance on similar prey resources. However, Atlantic salmon accumulate significantly lower quantities of Hg than Chinook salmon but are equal to coho salmon. Differences in life history, movement, and consumption rates may have contributed to lower Hg accumulation in Atlantic salmon compared to Chinook. From a food web perspective, increasing abundance of Atlantic salmon through stocking may be a preferred fisheries management strategy to reduce predator impacts on sensitive prey fish populations and reduce human exposure to Hg. *Keywords: Salmon, Stable isotopes, Mercury.*

GEZON, N.R.[1], HEWSON, I.[2], and STRYCHAR, K.B.[1], [1]Annis Water Resources Institute, 740 W. Shoreline Dr., Muskegon, MI, USA; [2]Cornell University, Ithaca, NY, USA. **Exploring the viral consortium of invasive quagga mussels in the Lake Michigan benthos.**

Quagga mussels (*Dreissena bugensis*) are a high impact invasive species in the Lake Michigan benthic community, making up a substantial portion of the nearshore and offshore biomass. Little is known about the viral community harbored within the invasive quagga mussels. This study used a metaviromic approach to isolate and identify the novel eukaryotic viruses found in the quagga mussels and also in sediment cores. Samples were collected in the nearshore and offshore waters between the ports of Holland and Muskegon in Lake Michigan. The results showed little overlap in the viral communities found in the mussels and the sediment cores, suggesting the viral community found in quagga mussels likely arrived with the invaders. Specific viral contigs were found in high abundance in the quagga mussel's metaviromes and future research seeks to understand the basic ecology of these quagga mussel specific viruses. *Keywords: Viruses, Quagga mussels, Lake Michigan.*

GILBERT, J.M., Wetland Ecologist/Private Consultant, 1117 North Road, RR#5, Langton, ON, N0E1G0, CANADA. **Assessing System Response and Impacts of Invasive *Phragmites australis* Control Activities.**

Effective management of invasive *Phragmites australis* (Phragmites) requires a number of site specific considerations including selection of the appropriate methods, control activity timing, presence of rare species and desired outcomes. Control activity becomes particularly challenging in sensitive habitats where even large, mono-dominant Phragmites cells can be interspersed among, or adjacent to, intact vegetation communities containing native species, including species at risk. Understanding the potential impacts versus benefits of control options is imperative for reducing harm to non-target species while achieving the desired restoration outcome. Monitoring for control efficacy, system response, and negative impacts due to activities such as herbicide application, prescribed fire, and cutting has occurred within a number of Ontario's Great Lakes Coastal Wetlands. The information acquired through this work is of relevance to land managers and others who have concerns about the harm versus benefit of controlling Phragmites within the systems they are looking to restore.
Keywords: Phragmites australis, Control systems, Monitoring.

GILL, D.G.[1], JOSHI, S.J.[1], and ROWE, M.[2], [1]School of Natural Resources and Environment, University of Michigan, 440 Church St., Ann Arbor, MI, 48109, USA; [2]Cooperative Institute for Limnology and Ecosystems Research, University of Michigan, 440 Church St., Ann Arbor, MI, 48109, USA. **Understanding the Potential Utility of the HAB Tracker Forecast Model for Western Lake Erie Anglers.**

The Lake Erie HAB Tracker forecast model was made available to the public through the NOAA Great Lakes Environmental Research Lab website in 2014, and improved versions have appeared in subsequent years. The HAB Tracker provides a nowcast and five-day forecast of the spatial distribution and transport of harmful algal blooms (HABs) in Lake Erie. To ensure that the HAB Tracker is useful to stakeholders, this study sought to assess the utility of the HAB tracker while exploring the information and tools Lake Erie anglers use for HAB decision making. In 2016, seven focus groups were conducted with charter captains and recreational anglers who fish the western and central basins to obtain feedback on the utility of the HAB Tracker and angler decision-making, perceptions, and existing knowledge of HABs. Using a grounded theory framework, analysis of emerging themes revealed that the perceptions of Lake Erie anglers varied regionally and correlated with sources of information. Most anglers sought to avoid fishing in HABs and found the HAB Tracker to be useful, because it complemented their use of MODIS satellite information. Those who did not find the HAB Tracker to be useful lived in areas not

frequently affected by HABs or expressed a distrust of scientific modelling or HABs research. *Keywords: Lake Erie, Stakeholder engagement, Harmful algal blooms, Public participation.*

GITAU, M.W., Purdue University, West Lafayette, USA. **Perspectives on Modeling Watershed Water Quality Responses and Best Management Practice Effects.**

Modeling and model-based approaches have now become integral methods of assessing pollutant fate and transport, determining land use/land management impacts, and quantifying Best Management Practice (BMP) effectiveness. Models provide a practical means through which underlying pollutant transport processes and patterns can be studied and location-specific responses can be obtained. Multiple BMPs can be studied simultaneously allowing the impacts of both individual BMPs and suites of BMPs to be determined. Models also offer a practical means of analyzing various "what-if" scenarios. In the Caloosahatchee River Watershed in South Florida, for example, a general decrease in total nitrogen and total phosphorus concentrations was observed between 1988 and 2009, this possibly being a reflection of management changes in the watershed and/or in the stream channel during that period. Studies in northwest Arkansas showed that concurrent implementation of agricultural best management practices served to protect water quality from otherwise adverse effects that might have occurred due to a rapid urbanization. In this presentation, recent and past experiences with model and model-based approaches are discussed, including work done in New York, Arkansas, Florida, and Indiana. Some key lessons learnt are highlighted. *Keywords: Water quality, Modeling, Watersheds.*

GLOEGE, L.J., MCKINLEY, G.A., MCINTYRE, P.B., and MOONEY, R.J., University of Wisconsin Madison, Madison, WI, 53706, USA. **The Fate of Tributary Loads to Lake Michigan.**

Nutrient and total suspended solids (TSS) loading are two stressors that degrade Great Lakes coastal ecosystems and the services they provide, such as drinking water, fisheries, and recreational opportunities. High nutrient inputs from urban and agricultural runoff continue to cause local eutrophication. A recent survey of Lake Michigan tributaries shows summer nutrient loads spanning three orders of magnitude, with higher values in regions dominated by agricultural and urban land use type. Understanding in more detail how vertical stratification and coastal circulation impacts the redistribution of tributary inputs in the coastal zone of Lake Michigan is imperative. Here, we use a three-dimensional hydrodynamic model of Lake Michigan to simulate this redistribution at the mouth of four tributaries during three thermal regimes: weak winter stratification, spring thermal front, and strong summer stratification. This is a first step in understanding how tributary load redistributions are impacted by the hydrodynamics of the coastal zone. In future work, we

will assess these processes across the full range of tributary load volumes and concentrations to assess how management efforts could be better targeted to protect the coastal zone. *Keywords: Lake Michigan, Hydrodynamic model, Tributaries.*

GLYSHAW, P.[1], VANDERPLOEG, H.A.[2], CAVALETTO, J.F.[2], RUTHERFORD, E.S.[2], WELLS, D.J.[1], NASH, R.D.M.[3], and GEFFEN, A.J.[4], [1]Cooperative Institute for Limnology & Ecosystem Research, Ann Arbor, MI, USA; [2]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, USA; [3]Institute of Marine Research, Bergen, NORWAY; [4]Department of Biology, University of Bergen, Bergen, NORWAY. **Potential effects of UV radiation on vertical distribution of zooplankton in Southeast Lake Michigan.**

Ultraviolet radiation has negative effects on both freshwater and marine zooplankton and likely plays a role in zooplankton vertical distribution, with many species avoiding surface waters where UV radiation is high. We hypothesized that increased water clarity caused by dreissenid mussel filtering may have allowed greater UV penetration, thus causing an increase in zooplankton depth distribution. Since 2013 we have measured UV radiation profiles at varying wavelengths in both UV-A and UV-B ranges along with PAR on a nearshore to offshore transect (15, 45, and 110 m) in Southeast Lake Michigan. During this time period we measured DOC, CDOM, and zooplankton vertical distribution using both traditional nets and an optical plankton counter. We report levels of UV radiation, attenuation depths, and attenuation coefficients in Lake Michigan and compare these to vertical distribution and biomass of different zooplankton species. We also estimated attenuation coefficients from 1983 to see if they can provide insight into the higher surface abundance of zooplankton found at that time. *Keywords: Zooplankton, Ultraviolet radiation, Lake Michigan.*

GOFFIN, M., Environment and Climate Change Canada, 4905 Dufferin Street, Toronto, ON, M3H 5T4, CANADA. **Restoring Great Lakes Areas of Concern Symposium.**

Areas of Concern have been a feature of the Great Lakes Water Quality Agreement between Canada and the United States since 1987. Initially, Areas of Concern (AOCs) shared Annex 2 to the Agreement with Lakewide Management Plans (LaMPs). The Agreement was revised in 2012 and AOCs are now profiled in a single annex, Annex 1. This change also included modifications to some of the provisions pertaining to AOCs impacting on how AOCs are to be addressed under the revised Agreement. In his opening remarks, Michael Goffin, the Regional Director General for Environment and Climate Change Canada in Ontario and one of the principal negotiators of the revised Agreement, will outline the purpose, objectives and implementation of the 2012 Great Lakes Water Quality Agreement with particular emphasis on the AOC Annex. He will also highlight the progress and priorities to restore the 14 remaining Canadian AOCs. *Keywords: Great Lakes basin, Areas of Concern, Water quality, Management.*

GOMEZDELCAMPO, E.[1] and WIJAYARATHNE, D.B.[2], [1]Bowling Green State University, School of Earth, Environment and Society, Bowling Green, OH, 43403, USA; [2]McMaster University, Department of Geography and Earth Sciences, Hamilton, ON, L8S 4L8, CANADA. **Modeling the hydrologic restoration of a wet prairie in the Maumee AOC.**

The hydrologic characteristics of the Oak Openings Region in Northwest Ohio, USA, a globally rare ecosystem in the Maumee AOC, are not well understood. Currently, the Oak Openings supports globally rare oak savanna and wet prairie habitats. The wet prairies in the region have been drained by ditches and encroached by invasive plants, which have altered the natural flow making it an unusually variable and artificial system. A shallow groundwater model was implemented using the Gridded Surface Subsurface Hydrologic Analysis (GSSHA) software to simulate the groundwater and surface water interaction in a small subwatershed in the Oak Openings Region. The implemented GSSHA model simulates physical processes such as infiltration, evapotranspiration, snowmelt, overland flow, and interaction of groundwater with ditches. The model was calibrated using a time series of water table elevations collected in the field. Three scenarios for hydrologic restoration, mainly related to ponding water depth, were implemented using the model. The first scenario included the effects if the whole subwatershed was restored to only wet prairie vegetation. The second scenario investigated the effect of removing all the main ditches present in the area. The third scenario considered the effect of removing the main ditch traversing the small subwatershed. *Keywords: Modeling, Watersheds, Wetlands.*

GOODFELLOW, B., DROUILLARD, K.G., and SEMENIUK, C.D., Great Lakes Institute of Environmental Research, Windsor, ON, CANADA. **Comparison of in situ bioenergetics of rainbow trout and bluegill sunfish.**

Gill elimination is well known as the main route of chemical elimination in fish. A dual tracer mechanism was designed to quantify fecal egestion efficiency and assimilation efficiency in two species of fish, rainbow trout (Oncorhynchus mykiss) and bluegill sunfish (Lepomis macrochirus). Fish were dosed with performance reference chemicals (PRCs) via intraperitoneal injection and fed a dosed meal containing a mixture of Aroclor PCBs. Fecal egestion efficiency was measured as the ratio of lipid normalized chemical concentration in feces to animal carcass. Chemical assimilation efficiency was measured as the ratio of chemical mass assimilated in fish tissues to the chemical mass ingested in the dosed meal.

Simultaneous determinations of dietary assimilation efficiency and fecal exchange efficiency were calculated using dual tracers, two sets of non-environmental PCB compounds, in the same fish, increasing statistical power. With these calibrated toxicokinetic paratmers, we will be able to test the assumption of the GI-magnification model that fecal egestion and chemical assimilation efficiencies are equal, and to correct or account for excess loss of chemical to feces to provide a more accurate estimate of routine metabolic rate in fish. *Keywords: Bioenergetics, Pollutants, Modeling.*

GORSKY, D., BIESINGER, Z., BRUESTLE, E., and KARBOSKI, C.T., U.S. Fish and Wildlife Service, 1101 Casey Rd, Basom, NY, 14013, USA. **The Lower Niagara River: breeding grounds of native species recovery in western Lake Ontario.**

The Niagara River is the connecting channel between Lakes Erie and Ontario and is an ecologically important corridor. The river is unique among Great Lakes connecting channels in that Niagara Falls presents an impassable barrier for fish, thereby splitting the river into separate functional ecosystems. The lower Niagara River is a complex system with many different habitats, characterized by differences in substrate, water flow, and bathymetry. These physical differences in turn create opportunities for diverse biological uses. The Niagara Gorge represents a unique habitat which plays an important role in the natural history and recovery of many native species. Highlighting two at-risk, native fish species showing signs of recovery, we discuss two research programs that have identified some services provided by unique Niagara Gorge habitats for Lake Trout and Lake Sturgeon. *Keywords: Lake trout, Lake Sturgeon, Fish behavior, Fish reproduction, Ecosystems, Connecting channel.*

GOULET, S.D.[1], PICARD, K.R.[1], LUGTEN, E.C.[1], TERRY, C.H.[1], WELNINSKI, A.D.[2], DILLER, S.N.[2], KOWALSKI, K.[2], and SCHAEFFER, J.S.[2], [1]University of Michigan, Ann Arbor, MI, USA; [2]U.S. Geological Survey Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105, USA. **Functional Assessment of Great Lakes Coastal Wetlands:Insights from Fish Diets.**

Great Lakes coastal wetlands serve as important fish nurseries and many fishes spend at least a portion of their life history in that habitat. But, coastal wetlands vary in quality; some are nearly pristine, while others have been degraded. We want to understand how variation in coastal wetland quality influences the ecological services they provide and are examining that relationship through the lens of juvenile fish production. For this study, we are analyzing the diets of 1048 juvenile fish representing 33 different species that were collected in Great Lakes coastal wetlands of varying quality during 2016. Our hypothesis is that higher quality wetlands confer higher quality diets for juvenile fishes that, in turn, lead to better growth, survival, and ultimately, greater juvenile fish production. We will present preliminary results of 2016 collection, and we hypothesize that fish diets from high quality collections will have more prey items, greater diet breadth, and more sensitive large-bodied macroinvertebrates such as amphipods, while fish diets in low quality wetlands will be comprised of smaller invertebrates such as chironomid larvae that can tolerate more stressful and low quality conditions. *Keywords: Coastal wetlands, Fish diets, Assessments.*

GRAY, D.K.[1], READ, J.S.[2], HOOK, S.[3], SCHNEIDER, P.[4], LENTERS, J.[5], O'REILLY, C.[6], SHARMA, S.[7], HAMPTON, S.[8], and CONTRIBUTERS, L.T.C.[9], [1]Wilfrid Laurier University, Waterloo, ON, CANADA; [2]US Geological Survey, Middleton, WI, USA; [3]NASA Jet Propulsion Laboratory, Pasadena, CA, USA; [4]Norwegian Institute for Air Research, Kjeller, NORWAY; [5]University of Colorado at Boulder, Boulder, CO, USA; [6]Illinois State University, Normal, IL, USA; [7]York University, Toronto, ON, CANADA; [8]Washington State University, Pullman, WA, USA; [9]Multi-institutional, World, USA. **Impact of measurement frequency and data gaps on the calculation of lake warming trends.**

The ability to accurately calculate warming trends and produce seasonal temperature estimates is an important prerequisite for assessing the impacts of climate change on lakes. Due to the nature of existing data sets, warming rates for many lakes have been calculated using low temporal resolution data (e.g. monthly measurements), or data that contains temporal gaps. For this study, we used simulated data sets, as well as high-resolution data from one large lake (Lake Tahoe, NV) and one small lake (Sparkling Lake, WI) to assess the impacts of measurement frequency and data gaps on estimates of seasonal temperatures and warming rates. Monte Carlo simulations were performed that involved introducing artificial data gaps and variability in the timing of temperature measurements. Our results indicate that measurement frequency has a significant impact on mean summer temperature estimates, with errors ranging from 0.01 to 0.4°C at measurement intervals between 2 and 30 days. Preliminary results also suggest that sampling frequency and data gaps significantly impact estimates of warming rates, and that the amount of error is influenced by the strength of the warming trend and the inherent variation in temperature data for the lake in question. *Keywords: Global warming, Climate change, Computer models.*

GREEN, D. and ADAMS, J.M., U.S. Environmental Protection Agency, 77 W. Jackson Blvd, G-17J, Chicago, IL, 60604, USA. **Measuring the Difference, Targeting Green Infrastructure in Great Lakes Shoreline Cities.**

Traditionally managing stormwater to be conveyed away as quickly as legally allowed often results in flooding, increased flashiness, erosion and ultimately pollutants entering the Great Lakes. In the Great Lakes Restoration Initiative Action Plan II, urban stormwater

runoff is identified as a problem and green infrastructure as part of the solution to improve nearshore water quality. U.S. EPA's Great Lakes National Program Office (GLNPO) has funded local governments to implement green infrastructure in strategic locations, investing almost $11 Million in 40 projects across the Great Lakes basin. In 2016, GLNPO began collaborating with USGS to measure the effectiveness of select green infrastructure projects. In this presentation, we will focus on green infrastructure projects and quantifying reduction of stormwater runoff, incorporating the important work of USGS on these metrics. Select projects highlighted have transformed publicly owned vacant lots with green infrastructure (Detroit, MI and Gary IN), installed green infrastructure in a former brownfield sites (Duluth, MN) and protected a bluff overlooking Lake Michigan (Oak Creek, WI).
Keywords: Urban watersheds, Green Infrastructure, Urban areas, Stormwater runoff, Watersheds, Flooding.

GREESON, E., TACIE, A., HART, B., and SIVY, T.L., Saginaw Valley State University, 7400 Bay Road, University Center, MI, 48710, USA. **Monitoring freshwater microbial contamination with qPCR rapid testing and source tracking methods.**

Current testing methods to measure microbial contamination have relied on an 18-24 hour incubation period in order to determine levels of fecal indicator bacteria, usually E. coli. These bacteria have shown a strong correlation with contact-associated illnesses, but the long analysis time could result in human contact with harmful pathogens. Our lab has continued to work with the EPA and Michigan DEQ to further adapt the rapid bacterial testing method known as EPA Method C: Escherichia coli in Water by TaqMan Quantitative Polymerase Chain Reaction (qPCR). During the summer of 2016, our testing of the Saginaw Bay Watershed expanded, with 5 sites in Huron County, 5 sites in Iosco County, and 5 sites in Bay County. The water samples were evaluated as either composites or triplicates in order to obtain at least 30 data sets for each site. Meanwhile, our objectives have expanded to use a qPCR method to identify the source(s) of microbial contamination in order for remediation to be undertaken. To this end, we have used qPCR primers and probes that differentiate between Bacteroides originating from human or bovine, with tests being run with samples from Isabella County in 2015 and the Pine River in 2016. The results thus far are very promising, with clear quantifications for the presence of Bacteroides from human and/or bovine. *Keywords: Indicators, Human health, Microbiological studies.*

GRIGORAKIS, S. and DROUILLARD, K.G., Great Lakes Institute for Environmental Research, 401 Sunset, Windsor, ON, N9B3P4, CANADA. **Effect of microplastics on dietary assimilation efficiency of PCBs by fish.**

Plastic pollution has resulted in microplastics becoming ubiquitous within marine and freshwater environments. Persistent organic pollutants (POPs) have the ability to sorb onto plastic. Furthermore, fish (and other organisms) have been shown to not only ingest microplastics in their native habitats, but to also assimilate POPs from microplastics in a lab setting. However, the degree to which POPs from microplastics assimilate in fish is unknown. As a result, this study aims to determine: (1) the assimilation efficiency (AE) of PCBs sorbed onto microplastics in fish and, (2) the relative contributions to whole body PCB assimilation between microplastics and their diet. To accomplish this, commercial fish pellets and microbeads each had a unique set of PCB congeners sorbed onto them. Microbeads were amended to fish pellets to create 6 treatment groups (0, 5, 10, 15, 20, 25% by weight) and goldfish were fed a single treatment pellet. After 48h the fish were sacrificed and their tissues were analyzed for PCBs. Because of the unique set of congeners, it is possible to determine the relative contribution that microplastic-sorbed PCBs have on whole body assimilation of PCBs. *Keywords: Assimilation Efficiency, Microplastics, PCBs.*

GRONEWOLD, A.D.[1] and SMITH, J.P.[2], [1]NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Rd., Ann Arbor, MI, 48108-9719, USA; [2]CILER, G110 Dana Building 440 Church Street, Ann Arbor, MI, 48109-1041, USA. **Great Lakes water budget modelling and uncertainty estimation under a Bayesian MCMC framework.**

Between the 2 years of 2013 and 2014, Lakes Superior and Michigan-Huron experienced one of the greatest rises in water level for the 100+ year period of record. Seeking the climatological drivers of the level rise, Gronewold et al. (2016) developed a provisional Markov Chain Monte Carlo (MCMC) model under a Bayesian framework that helped reconcile different model forcings of water budget components over the 2 lakes, and effectively close the water balance, making robust inference about primary drivers of water level rise possible. This talk discusses the model, recent work on the model to improve efficiency and ease of use in an operational setting, and current work to extend the model across all Great Lakes from 1950 to present. *Keywords: Hydrologic budget, Water level, Mathematical models.*

GUEGUEN, M.E., Science and Arts Academy, 1825 Miner Street, Des Plaines, IL, 60016, USA. **Project STREAMS Green Infrastructure.**

Seventh and eighth graders at Science & Arts Academy in Des Plaines, Illinois are the creators of an innovative and creative project entitled "Project STREAMS (Saving The River Environment And Maintaining Streams)". Upon learning that two sewage plants and 70 businesses dispose of waste in the Des Plaines River near their school, through researching the EPA watershed and other government websites, students decided to take

action. According to the Illinois Environmental Protection Agency (IEPA), roughly 20% of the Des Plaines River is so dirty that it is not safe for swimming or fishing. Project STREAMS' focus is to reduce pollution and its negative effects on aquatic life through the use of green infrastructure. Students planted a Riparian buffer zone on the banks of the river to block harmful runoff, prevent erosion, and provide food for aquatic life. Working with a local naturalist, they have planted buttonbushes in Zone 1, added protective caging around young oak trees in Zone 3, and removed invasive species from the surrounding forest area. In year two, Project STREAMS has collected baseline data using a hydrolab on two sites along the river, developed an education program for younger children, and are in the process of growing the native plants needed to expand the existing Riparian buffer.
Keywords: Watersheds, Green Infrastructure, Water quality, Storm water runoff, Pollution sources, Pollution prevention.

GUILDFORD, S.J.[1], VERBURG, P.[2], ALBERT, A.[2], and HECKY, R.E.[1], [1]University Minnesota Duluth, Large Lakes Observatory, Duluth, MN, USA; [2]National Institute Water & Atmosphere, Hamilton, NEW ZEALAND. **Do nutrients or light control phytoplankton growth rates in Lake Taupo in winter?**

Lake Taupo (area 616 km2, max depth 163 m) is New Zealand's largest lake and unlike North American Great Lakes is managed under a nitrogen (N) loading cap. It is monomictic with winter circulation occurring at temperatures greater than 10 C. Maximum annual phytoplankton biomass in this oligotrophic lake occurs during winter. Previous research has suggested that N limits phytoplankton growth in winter. We used nutrient status indicators to evaluate whether phytoplankton were deficient in N or phosphorus (P) or were in balanced growth under light limitation. Long term monitoring of the stoichiometry of seston carbon (C), N and P indicated that in winter phytoplankton were less nutrient stressed than in summer. Dissolved inorganic P and N were low in winter although higher than summer when they were often undetectable. At the end of winter mixing (September 2016) we measured physiological indicators of nutrient deficiency (P and N debt, phosphatase activity) at 10 and 50 m. No nutrient deficiency was apparent with these indicators. Mean water column light was low and may have been limiting phytoplankton growth. These same indicators in summer of 2015 indicated extreme P deficiency and moderate N deficiency. We conclude that light rather than nutrients control phytoplankton growth in winter while nutrients control summer growth. *Keywords: Nutrients, Nitrogen, Phytoplankton, Light, Phosphorus.*

GUNN, G.E. and HALL, D.K., Michigan State University, 673 Auditorium Road, East Lansing, MI, 48824, USA. **Microwave Scattering Mechanisms of Snow-Covered Freshwater Lake Ice in Western Michigan - GLAWEX-17.**

Many active microwave observation and modeling studies for lake ice employ the hypothesis that the dominant scattering mechanism in ice is of double-bounce nature, caused by vertical tubular bubble inclusions (Weeks et al., 1981, Gherboudj et al., 2010). Recent advances in satellite technology offer fully polarimetric data and target decompositions, which indicate single-bounce interactions are most common in floating ice, which has been hypothesized (absent field observations) to be caused by roughness at the ice-water interface.This study presents radar and in-situ physical observations of small lakes in western Michigan acquired during the Great Lakes Winter Experiment 2017 (GLAWEX'17). In conjunction with NASA's SnowEx airborne snow campaign (http://snow.nasa.gov), dual-frequency (X-, Ku-band) SnowSAR acquisitions will be acquired for two small lakes in western Michigan; Fremont (43.450° -85.966°) and Nichols Lake (43.726° -85.905°). Airborne SAR acquisitions are temporally coincident to spaceborne SAR observations (RADARSAT-2, TerraSAR-X) and in-situ measurements of physical snow and ice parameters. Small/large scale roughness features at the ice-water interface are quantified using submersible LiDAR and auger transects, respectively, and for the first time used as an input variable in lake ice backscatter models. *Keywords: Ice, Active microwave, Remote sensing, Scattering mechanisms.*

GUO, C., Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences, 73 East Beijing Road, Nanjing, JS, 210008, CHINA. **The Extreme Weather Event Induced Microcystis Blooms in Qiantang River, China.**

The Qiantang River is the longest river in Zhejiang Province, southeastern China. The Qiantang River provides 85% of drinking water supply for Hangzhou City. Based on the 15 samplings along the Qiantang River in summer including Qujiang River, Jinhua River, Xinanjiang River and Fuchunjiang River/Reservoir, a preliminary analysis was carried out for the outburst of blue-algae blooms in Qiantang River, 2016. Laboratory investigation revealed that different algae groups are dominant in tributaries, i.e. diatom in Qujiang and Xinhua Rivers, green alga in Jinhua River whereas several groups were found in Lanjiang River. The blue-algae are absolutely dominant in Fuchunjiang River/Reservoir, among which Microcystis aeruginosa, M. botrys, M. wesenbergii contributed most with an extreme biomass of 51.409mg/L in certain profiles, showing the severest blooms in the whole river/reservoir. Investigations on the meteorological, hydrological as well as nutrient characteristics indicated that exceptionally longer hot weather from mid-July to late August was the key triggering factor that induced the river/reservoir bloom. In addition, the extreme

low running water from Lanjiang River after mid-July favored the bloom, and the nutrient backgrounds from Jinhua and Lanjiang Rivers supported the bloom in the Qiantang River. *Keywords: Harmful algal blooms, Extreme weather, Microcystis, Reservoirs.*

GUO, J.[1], ROMANAK, K.[1], VENIER, M.[1], WESTENBROEK, S.[2], LI, A.[3], and HITES, R.A.[1], [1]Indiana University - Bloomington, Bloomington, IN, USA; [2]United States Geological Survey, Middleton, WI, USA; [3]University of Illinois at Chicago, Chicago, IL, USA. **Mass Balance Study of Lake Michigan for Polychlorinated Biphenyls in 2010-2015.**

This study revisits and updates the Lake Michigan Polychlorinated Biphenyl (PCB) Mass Balance Study conducted in 1994-96. The current work uses recent concentrations of PCBs in tributary water, air, open lake water, and sediment to calculate an updated mass balance for these legacy pollutants. Water samples, including both dissolved and particle phases, were collected every 3 weeks in 2015 from the Grand, Kalamazoo, St. Joseph, and Lower Fox Rivers and from the Indiana Harbor and Ship Canal. Air (vapor phase) and precipitation samples were obtained from Chicago and Sleeping Bear Dunes as part of the U.S. Integrated Atmospheric Deposition Network. Open lake water samples collected in 2012 had been previously analyzed in the Hites laboratory in collaboration with Environment Canada. Sediment data collected in 2010-11 were obtained from Li laboratory as part of the Great Lakes Sediment Surveillance Program. Monte Carlo simulation, assuming a normal distribution for each parameter, was used to estimate the fluxes, including wet deposition, tributary loadings, sediment-water exchange, air-water exchange, sedimentation and outflow to Lake Huron and Chicago Diversion. Tributary loadings and atmosphere deposition have decreased compared to those from 1994-95. These results suggest that sediment is now acting as a secondary source. *Keywords: Mass balance, Environmental contaminants, Tributaries.*

GUTHRIE, A.G.[1], TAYLOR., W.W.[1], FRANK, K.[1], MUIR, A.[2], and REGIER, H.A.[3], [1]Michigan State University, 480 Wilson Road, Room 13, East Lansing, MI, 48824, USA; [2]Great Lakes Fishery Commission, 2100 Commonwealth Blvd, Suite 100, Ann Arbor, MI, 48105, USA; [3]University of Toronto (retired), 27 King's College Circle, Toronto, ON, M5S 1A1, CANADA. **Collaboration Networks Supported the Adoption of Ecosystem-based Management.**

The evolution of ecosystem-based management in the Great Lakes Basin provides insight on the development of multi-governance fishery management. Ecosystem-based management incorporates physical, societal, and biological components in decision making, aiming to improve natural resource sustainability. The study objective was to evaluate how ecosystem-based management evolved and disseminated throughout the Basin to support

fisheries. Using Social Network Analysis techniques, we determined ecosystem-based management concepts spread during meetings and workshops. Our analysis depicted key individuals and "bridgers" - who linked science and governance agencies - were crucial for knowledge dissemination that lead to ecosystem-based management implementation. The structure of the Great Lakes Fishery Commission and Lake Committee Meetings were important for identifying ecosystem-based strategies and decisions to assist fisheries rehabilitation. Workshops hosted by the Great Lakes Fishery Commission (i.e. Salmonid Communities on Oligotrophic Lakes) advanced the science within the Basin by hosting worldwide researchers to discuss issues facing fisheries and propose solutions using a more holistic ecosystem-based approach. Holistic management depends on flow of knowledge between science, policy, and agencies in joint decision making. *Keywords: Ecosystems, Fish management, Environmental policy.*

H

HAEFNER, R.J., U.S. Geological Survey, 6520 Mercantile Way, Suite 5, Lansing, MI, 48911, USA. **Stormwater Reduction from Green Infrastructure through Collaborative USEPA and USGS Research.**

Problems from urban stormwater in the Great Lakes basin include flooding, combined sewer overflows, and degraded water quality from surface runoff. The U.S. Geological Survey and U.S. Environmental Protection Agency (through the Great Lakes Restoration Initiative, GLRI) in collaboration with local partners from Buffalo, New York; Detroit, Michigan; and Gary, Indiana are investigating stormwater volume reduction related to green infrastructure. An internal database describing GLRI-funded green infrastructure projects within the Great Lakes basin was compiled in 2015. Of approximately 70 sites in the basin, three were selected based on project scale, location, characteristics of green infrastructure implemented, and timing of construction. In 2016, the three sites were instrumented with weather stations, flow meters, soil-moisture probes, groundwater wells, flumes, and other devices to calculate stormwater reduction efficiencies through quantification of the flows into and out of the green infrastructure. Our research focuses on developing meaningful metrics to compare and contrast stormwater reduction between different types of green infrastructure in different settings, and explaining uncertainty related to our ability to make sufficiently precise measurements that allow for comparison of components of the urban water cycle. *Keywords: Urban watersheds, Stormwater, Great Lakes Restoration Initiative (GLRI), Green infrastructure, Zooplankton.*

HAGLEY, C.A.[1], BILOTTA, J.[2], TEPAS, K.M.[3], HOFFMAN, J.C.[4], GUTSCH, M.K.[4], KITSON, M.[1], and KLINE, K.S.[5], [1]Minnesota Sea Grant, 31 W. College St., Duluth, MN, 55812, USA; [2]Minnesota Sea Grant, Minnesota Extension, 173 McNeal Hall, 1985 Buford Ave, St. Paul, MN, 55108, USA; [3]Illinois-Indiana Sea Grant, GLNPO, 77 W. Jackson Blvd, Chicago, IL, 60604, USA; [4]U.S. EPA Mid-Continent Ecology Division, 6201 London Rd, Duluth, MN, 55804, USA; [5]University of Wisconsin Sea Grant Sea Grant Institute, 1975 Willow Drive, Madison, WI, 53706, USA. **Shipboard Experiences Unite Scientists with Educators and Decision-Makers for Lasting Impacts.**

The confined, immersive, and hands-on environment aboard a ship is an excellent venue for building a community of practice related to researching, teaching about, and managing aquatic resources and surrounding lands. Communities of practice bring people together around collective learning experiences. The close interactions and shared learning that take place in this type of environment have been shown to yield lasting interactions and positive impacts on scientists, educators, and local decision-makers, particularly when followed by continued support and interaction. The Center for Great Lakes Literacy and associated Sea Grant programs, as well as the Northland NEMO program, have conducted shipboard workshops of varying length on a number of vessels for many years. Lessons learned; guiding principles; and evidence of benefits to scientists, educators, and decision-makers (and the constituents they serve) will be shared. *Keywords: Education, Watersheds, Outreach.*

HALFMAN, J.D.[1], RAZAVI, R.[2], and CLECKNER, L.[2], [1]Hobart & William Smith Colleges, Dept of Geoscience / Environmental Studies, Geneva, NY, 14456, USA; [2]Hobart & William Smith Colleges, Finger Lakes Institute, Geneva, NY, 14456, USA. **Nutrient Loading Trigger for Blue-Green Algae Blooms in the Finger Lakes, New York.**

Like the Great Lakes, water quality issues like blue-green aka harmful algal blooms (HABs) have negatively affected the Finger Lakes (FL) in central New York. The oligotrophic to eutrophic FLs experience similar water quality issues as the Great Lakes thus provide an ideal natural laboratory to investigate issues impacting the Great Lakes but are smaller thus easier to study. In this poster, we present a decade of monthly, offshore, mid-lake, water quality monitoring data from the eight eastern FLs and daily data from two autonomous YSI/Xylem water quality buoys to investigate potential triggers for the onset of HAB blooms. Shallower Secchi depths, and larger nutrient, suspended sediment and chlorophyll-a concentrations reflecting declining water quality in 2011 and again in 2014/2015, coincided with the onset of toxic BGA blooms in six of the eleven FLs. It suggests that regional nutrient loading issues initiated localized, nearshore blooms. Specific nearshore blooms occurred after summer solstice, maximum air and water temperatures, and

rainfall events, but typically waited for calm or near calm sunny conditions to occasionally bloom. Southerly winds paralleled the more northern location of the detected nearshore blooms. Finally, some of the mesotrophic and oligotrophic FLs experienced blooms.
Keywords: Nutrients, Blue-green algae, Water quality, Algae.

<u>HALL, D.K.</u>[1], NGHIEM, S.V.[2], GUNN, G.E.[1], LESHKEVICH, G.[3], HELFRICH, S.R.[4], CRAWFORD, C.J.[5], KEY, J.R.[6], CZAJKOWSKI, K.P.[7], RIGOR, I.G.[8], and KIM, E.J.[9], [1]Michigan State University, 673 Auditorium Drive, East Lansing, MI, 48824, USA; [2]NASA/Jet Propulsion Lab, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA, 91109, USA; [3]NOAA/Great Lakes Environmental Research Lab, 4840 S. State Road, Ann Arbor, MI, 48108, USA; [4]NOAA/U.S. National Ice Center, 4231 Suitland Road, Suitland, MD, 20746, USA; [5]University of Maryland/ESSIC, 5825 University Research Court, College Park, MD, 20740, USA; [6]NOAA/NESDIS, 1225 W. Dayton Street, Madison, WI, 53706, USA; [7]University of Toledo, 2801 W. Brantford Road, Toledo, OH, 43606, USA; [8]University of Washington/APL, 1013 NE 40th Street, Seattle, WA, 98105, USA; [9]NASA/Goddard Space Flight Center, 8800 Greenbelt Road, Greenbelt, MD, 20771, USA. **GLAWEX'17 - Snow and Ice Field and Aircraft Experiment in Michigan and the Great Lakes.**

The Great Lakes Winter Experiment 2017 (GLAWEX'17), an ice and snow field and aircraft experiment, is the most recent in a series of GLAWEX campaigns that began in 1997. GLAWEX'17 represents a collaborative effort of NASA, NOAA, US Coast Guard (USCG), and many other institutions. The Great Lakes region offers the opportunity to study a range of snow conditions representing snow of different depths in varied landscapes, and also the opportunity to study ice thickness and composition on small, frozen lakes as well as on the Great Lakes. In conjunction with NASA's SnowEx airborne snow campaign [http://snow.nasa.gov], an instrumented Naval Research Lab P-3 aircraft will fly over Green Bay, Lake Michigan, western Michigan, Toledo, OH, and Lake Erie in February 2017. Field teams will be deployed over a 65-km flight line in the Manistee National Forest, to test the capabilities of microwave sensors for snow-water equivalent retrieval over a gradient of snow-covered forest, and snow on lake ice. Students in Toledo will acquire ground measurements to support an existing NASA education project. In-situ measurements of ice in Green Bay, and measurements and buoy deployments in Lake Erie will be undertaken to validate satellite products of ice-type classification, and to test new algorithms for detection and mapping of snow-covered ice. *Keywords: Lake Michigan, Remote sensing, Lake Erie.*

<u>HAMLET, A.F.</u>, CHIU, C.M., SHARMA, A., BYUN, K., and HANSON, Z., CEEES, University of Notre Dame, 156 Fitzpatrick Hall, University of Notre Dame, Notre Dame,

IN, 46566, USA. **Developing Flexible, Integrated Hydrologic Modeling Systems for Multiscale Analysis in the Midwest.**

Physically based hydrologic modeling of surface and groundwater resources that can be flexibly and efficiently applied to support water resources policy/planning/management decisions at a wide range of spatial and temporal scales are greatly needed in the Midwest, where stakeholder access to such tools is currently a fundamental barrier to basic climate change assessment and adaptation efforts. Driving data for our integrated model is composed of historical and projected future meteorological data based on station observations and statistically and dynamically downscaled climate model output respectively. Surface water is simulated by the macro-scale VIC hydrologic model implemented over the Midwest at 1/16 degree resolution. High-resolution climate model (4km WRF) output provides inputs for the analyses of urban impacts, hydrologic extremes, agricultural impacts, and impacts to the Great Lakes. Groundwater recharge estimated by VIC provides input data for fine-scale and macro-scale groundwater models. We briefly describe three current case studies addressing different spatial scales of analysis: 1) Indiana Climate Change Impacts Assessment, 2) Integrated surface and groundwater modeling in the Kankakee River basin, 3) Effects of climate change on carbon cycling in small lakes in the Northern Highland Lakes District. *Keywords: Climate change, Climate modeling, Surface water modeling, Groundwater modeling.*

HAMPEL, J.J.[1], MCCARTHY, M.J.[1], GARDNER, W.S.[2], XU, H.[3], ZHU, G.W.[3], ZHANG, L.[3], and NEWELL, S.E.[1], [1]Wright State University, Dayton, OH, 45435, USA; [2]University of Texas Marine Science Institute, Port Aransas, TX, 78373, USA; [3]Nanjing Institute of Geography and Limnology, Nanjing, CHINA. **Water column ammonium dynamics in two large, eutrophic, freshwater lakes: Lakes Taihu and Okeechobee.**

Lakes Taihu (China) and Okeechobee (Florida) are large, shallow, eutrophic lakes that experience seasonal harmful algal blooms. These *Microcystis spp.* blooms proliferate in aquatic ecosystems due to eutrophication, triggered by high external inputs of nitrogen and phosphorus. As non-N_2-fixers, *Microcystis spp.* must compete with other primary producers, such as ammonia-oxidizing organisms, for combined nitrogen (e.g., ammonium). This competition may alter nitrification (ammonia and nitrite oxidation) and, subsequently, denitrification rates in lakes. To investigate the competition for ammonium, we used ^{15}N stable isotope additions to quantify water column rates of ammonium regeneration and potential uptake and compared them to ammonia and nitrite oxidation rates. Our data show that, outside of the bloom, ammonia oxidation dominated total ammonium uptake and could be sustained by regeneration. However, during the high bloom season, uptake rates exceeded ammonia oxidation rates, suggesting that non-N_2-fixing cyanobacteria were outcompeting nitrifiers. Nitrite oxidation rates were higher than ammonia oxidation rates, suggesting that nitrate reduction by photoautotrophs and subsequent nitrite oxidation by nitrifiers might play a significant role. *Keywords: Microcystis, Nitrogen, Nutrients.*

HANLEY, M.F., Ontario Ministry of Natural Resources and Forestry, 41 Hatchery Lane, Picton, ON, K0K 2T0, CANADA. **Changes in the Ecology and Abundance of Smallmouth Bass in Lake Ontario: 1958-2014.**

Long-term changes in indices of Smallmouth Bass condition and population levels were examined for eastern Lake Ontario and the Bay of Quinte. Smallmouth Bass have experienced numerous changes in their environment through direct human impacts, climate change, predation, and habitat sharing with non-native species. Smallmouth Bass have experienced an increase in body length and weight likely due to a diet shift from crayfish to predominantly Round Gobies which has allowed them to increase their growth rate. According to existing assessment data however, this increase in body size has not been associated with an increase in abundance. Long-term data from gillnet sampling shows that Smallmouth Bass populations have been declining since the late 1980s with no indication of recovery. This is likely due to a change in the selectivity of gillnets because of the change in body size as well as a habitat shift away from gillnet sampling sites. Adjusting for gillnet selectivity has revealed that sub-adult bass abundance is currently greater than it was historically, and that very large bass are likely not being retained within the gillnets that are currently used. The use of a long-term data set in this study has led to a much better understanding of Smallmouth Bass abundance and ecology. *Keywords: Fish populations, Long-term Data set, Bay of Quinte, Smallmouth Bass, Lake Ontario.*

HANSEN, T.H., University of Wisconsin-Milwaukee School of Freshwater Sciences, 600 E. Greenfield Ave, Milwaukee, WI, 53204, USA. **Investigating the use of existing single-beam bathymetric data for sediment and biotope analysis.**

We will present a status report of an ongoing research program leveraging existing compilations of benthic data sources to perform mapping and analysis of benthic habitats in selected sites in Lake Michigan. Two contrasting areas are targeted for analysis: the nearshore, including and in the vicinity of the harbor of the City of Milwaukee; and a midlake reef which is part of the Mid-Lake Reef Complex. We are using as a starting point techniques similar to what was demonstrated in Elvenes, et.al (Elvenes, S., Dolan, M.F.J., Buhl-Mortensen, P., and Bellec, V.K. An evaluation of compiled single-beam bathymetry data as a basis for regional sediment and biotope mapping. - ICES Journal of Marine Science). The data we have compiled resemble in type and quantity with the data used in that study: a large quantity of single-beam soundings with limited multibeam data as a supplement. We are currently proceeding with compiling and performing spatial statistical analysis on a large single-beam bathymetry dataset amassed over the course of a decade. We are using other datasets, primarily from multibeam sonar surveys, to inform and calibrate this statistical analysis, with the aim of producing meaningful predictions of benthic habitat characteristics. Future directions of our research will also be summarized. *Keywords: Spatial distribution, Single-beam sonar, Computer models, Multibeam sonar, Hydrodynamic model.*

HAPPEL, A.[1], CZESNY, S.J.[1], and RINCHARD, J.[2], [1]Lake Michigan Biological Station, Illinois Natural History Survey, Univeriesty of Illinois, 1816 S Oak Street, Champaign, IL, 61820, USA; [2]The College at Brockport, 390 New Campus Drive, Brockport, NY, 14420, USA. **Consumption of Forage Fish Alters Fatty Acids of Brown Trout Eggs.**

In an effort to better understand the effects diet composition has on salmonid species we feed captive brown trout diets consisting of mixtures of two invasive species. Alewife and round goby were offered to brown trout in isolation and in 70:30 mixtures based on wet weight for a period of 11 months. Fatty acid profiles of belly flaps and eggs were analyzed along with the thiamine content of eggs. In samples of belly flap proportions of oleic acid (18:1n-9) and fatty acids of the n-3 family in both belly flap and eggs proportions increased with increasing consumption of alewife. Conversely, fatty acids in the n-7 family and branched-chain fatty acids increased in both tissue types when round goby comprised larger portions of the diet composition. We noted that a diet of only round goby produced higher and more variable concentrations of free thiamine in brown trout eggs compared to other treatments. Our data indicates that diet compositions influence the supply of essential nutrients to brown trout embryos. Furthermore, our data indicates that thiamine deficiency complex could be related to a diet supplying a high concentration of n-3 fatty acid depleting maternal thiamine reserves. *Keywords: Fish diets, Alewife, Salmon.*

HARBICHT, A.B.[1], FRASER, D.[1], CASTRO-SANTOS, T.[2], GORSKY, D.[3], HAND, D.[4], and ARDREN, W.R.[5], [1]Concordia University, Montreal, QC, CANADA; [2]U.S. Geological Survey, Turner Falls, MA, USA; [3]U.S. Fish and Wildlife Service, Lower Great Lakes Fish and Wildlife Conservation Office, Basom, NY, USA; [4]U.S. Fish and Wildlife Service, Columbia River Fisheries Program Office, Vancouver, WA, USA; [5]U.S. Fish and Wildlife Service, Lake Champlain Fish and Wildlife Conservation Office, Essex Junction, VT, USA. **Does boosting thiamine levels of Atlantic salmon enhance upstream migration?**

Efforts to reintroduce landlocked Atlantic salmon in Lake Champlain are being hindered by introduction of alewife in 2003. Consuming alewife has decreased thiamine levels within salmon, potentially reducing migration performance due to impaired equilibrium and muscle weakness. In the fall of 2014, we used radio telemetry to quantify upstream migration performance of 24 adult salmon in the Boquet River at a steep cascade section located downstream of suitable spawning habitat. Half of these fish were injected with thiamine booster shots. All but one experimental fish continued upstream and held in a large pool just below the cascade for an average of 21 days. We quantified the extent, duration and frequency of attempts to climb the cascade for each fish using a novel method to continuously monitor fine-scale movement. Thiamine boosted salmon had significantly improved migratory ability in the cascade with reduced time required to migrate up a series of rapids with in the cascade and diminished time between migration attempts. Only two thiamine boosted and one nonboosted fish successfully migrated upstream of the cascade. Our results suggest decreased thiamine levels reduced migration performance of salmon at the cascade which in turn reduced the recolonization potential for salmon in this river. *Keywords: Salmon, Thiaminase, Fish behavior.*

HARDER, A.M.[1], ARDREN, W.R.[2], and CHRISTIE, M.R.[1], [1]Dept. of Biological Sciences, Purdue University, West Lafayette, IN, 47907, USA; [2]U.S. Fish and Wildlife Service, Essex Junction, VT, 05452, USA. **Overview of Thiamine Deficiency Complex and Identification of Underlying Genetic Mechanisms.**

Thiamine deficiency complex (TDC) is a disorder resulting from the inability to acquire or retain thiamine, and has been documented in aquatic systems ranging from the Baltic Sea to the Laurentian Great Lakes. While the root causes of TDC may vary among systems, one common outcome is the decline of salmonid populations due to diminished natural recruitment. In the Great Lakes and Lake Champlain, eggs of stocked salmonids are now treated with supplemental thiamine to mitigate otherwise high rates of juvenile mortality. Previous research has indicated that genetic differences between populations (*i.e.*, strains) of Atlantic salmon may contribute to variation in susceptibility to thiamine deficiency. We will provide an overview of biomolecular pathways dependent on thiamine and general physiological consequences of thiamine deficiency. We will also explore current hypotheses and outstanding questions regarding ecological factors contributing to TDC in the Great Lakes. Lastly, we will conclude with a brief discussion of ongoing research that seeks to identify genetic markers associated with increased tolerance to low tissue thiamine concentrations. *Keywords: Salmon, Thiaminase, Genetics.*

HARDY, S.D. and BARTOLOTTA, J.F., Ohio Sea Grant, 1314 Kinnear Road, Columbus, OH, 43212, USA. **Barriers and benefits to desired behaviors for single-use plastic items in Northeast Ohio.**

Given the growing saliency of plastic marine debris, and the impact of plastics on beaches and aquatic environments in the Laurentian Great Lakes, applied research is needed to support municipal and nongovernmental campaigns to prevent debris from reaching the water's edge. This study attempts to accomplish this goal examining the barriers and benefits to positive behavior for three plastic debris items in northeast Ohio's Lake Erie basin: plastic bags, plastic water bottles, and plastic cigar tips. An online survey and focus group were employed to gather data on the use and disposal of these plastic items in the Cleveland area, and to solicit recommendations on how to positively change behavior to reduce improper disposal. The results from this project will be used to inform a social marketing campaign broadcast throughout Cleveland in the summer of 2017, as well as to serve as a pilot for related research on plastic marine debris in other Great Lakes states. *Keywords: Consumer-based social marketing, Social science, Lake Erie, Plastic marine debris, Public education.*

HARRIS, C.S., American Chemistry Council, Plastics Division, Washington, DC, USA. **Plastics Producers Solutions on Marine Litter: 2016 Progress Report.**

A 2015 study published in Science estimated that 4.8 to 12.7 million metric tons of plastic waste enter our oceans annually, with the origin of marine litter closely related to populations concentrated near oceans and the quality of waste management systems. Although research shows the environmental cost of using plastics is nearly four times less than would result if plastics were replaced with alternative materials in key applications, marine litter must be reduced. In March 2011, leaders from 47 plastics associations across the globe launched a Declaration of the Global Plastics Associations for Solutions on Marine Litter, a public commitment to help tackle the global problem of plastic litter in the marine environment. These industry leaders identified six areas for initiatives aimed at contributing to sustainable solutions: education, research, public policy, sharing best practices, plastics recycling/recovery, and plastic pellet containment. By December 2015, 260 projects had been planned, were underway, or completed; an increase of more than 165% in the number of projects since the Declaration was announced. The projects vary widely, from enhanced recycling to beach clean ups, and from global research to awareness and education campaigns; and include examples of innovative approaches to private sector engagement. *Keywords: Outreach, Plastic, Marine Environment.*

HARTIG, J.H.[1] and WYMA, R.J.H.[2], [1]U.S. Fish and Wildlife Service, Detroit River International Wildlife Refuge, 9311 Groh Road, Grosse Ile, MI, 48138, USA; [2]Essex Region Conservation Authority, 360 Fairview Avenue West, Suite 311, Essex, ON, N8M 1Y6, CANADA. **Habitat rehabilitation in the Detroit River Area of Concern.**

Loss and degradation of fish and wildlife habitat is a long-standing issue in the Detroit River watershed. The Detroit River Remedial Action Plan helped agencies and stakeholder groups reach agreement on impaired beneficial uses, including loss of fish and wildlife habitat, and helped mobilize all stakeholders to rehabilitate habitat. Many organizations played key roles, including the American and Canadian Heritage River Initiatives, Detroit River International Wildlife Refuge, Western Lake Erie Watersheds Priority Natural Area, Detroit River Canadian Cleanup, Detroit River Public Advisory Council, and others. Highlights of accomplishments include: 53 soft shoreline engineering projects have been implemented in the watershed; five sturgeon spawning reefs have been constructed in the Detroit River, common tern habitat has been restored in four locations; and many wetland and green infrastructure projects have been completed. Key lessons learned include: involve habitat experts up front in project design; establish quantitative targets for project success; ensure sound multidisciplinary technical support; start with demonstration projects; treat habitat projects as experiments; involve citizen scientists in monitoring; measure benefits; communicate and and celebrate successes; and promote promote education and outreach. *Keywords: Habitats, Detroit River, Impared water use.*

HAWLEY, N.[1], BELETSKY, D.[2], WANG, J.[1], and CHU, P.[1], [1]Great Lakes Environmental Research Laboratory, 4840 S. State Rd., Ann Arbor, MI, 48108, USA; [2]Cooperative Institute for Limnological and Ecosystems Research, 4840 S. State Rd., Ann Arbor, MI, 48108, USA. **Time series measurements of ice thickness in Lake Erie, 2010-2011.**

Time series measurements of ice thicknesses were made at 6 locations in the western part of Lake Erie's central basin during the winter of 2010-2011. Ice was observed over approximately 80 days beginning in late December and continuing through mid-March. Deformation and rafting of ice occurred frequently and produced ice thicknesses of up to 10 m, and over 6 m at all stations. The measurements show considerable variability between stations, even when the distance between them is less than 500m. Comparison of the measurements to those generated by the National Ice Center show good agreement for undeformed thicknesses, but the Ice Center analyses do not account for increased thicknesses due to ice rafting. Several different measures of ice thickness are used to characterize the data. The best measure to use probably depends upon the use for which the data is intended. *Keywords: Lake Erie, Ice.*

HE, J.X.[1] and BENCE, J.R.[2], [1]Michigan DNR Fisheries, 160 East Fletcher Street, Alpena, MI, 49707, USA; [2]MSU Fisheries and Wildlife, 480 Wilson Road, Room 13, East Lansing, MI, 48824, USA. **Time-varying Components in Stock Assessments: A Procedure for Selection of Statistical Options.**

Fishery stock assessment often needs to address variation and changes in recruitment, catchability and selectivity. For each of these time-varying processes in assessment models, four statistical options are typically considered: time-invariant, random walk, white noise, and the first order of autoregressive. The first three options are special cases of the last. The complexity is increased further when time-varying catchability and selectivity need to be applied to multiple sources of data, including commercial fishery, recreational fishery, and fishery independent surveys. We developed a procedure to compare and select the best model that involves various options for estimating time-varying components of a stock assessment model. Viable models were those that (a) converged, (b) showed reasonably consistent patterns as years of data were added or removed, and (c) estimated plausible levels of observation and process variance. We selected among viable models based on Deviance Information Criterion (DIC), which is similar as AIC but is typically used in Bayesian statistical models. We also discussed model averaging and use of WAIC and cross-validation measures of model fit. We illustrated our procedure using the example of lake trout stock assessment in northern Lake Huron. *Keywords: Model Comparison and Selection, Time-varying models, Fishery Stock Assessment.*

HE, J.X.[1], FIELD, D.G.[1], ROSEMAN, E.F.[2], and DOBIESZ, N.E.[3], [1]Michigan DNR Fisheries, 160 East Fletcher Street, Alpena, MI, 49707, USA; [2]USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105, USA; [3]MSU Quantitative Fisheries Center, 375 Wilson Road, Room 101, East Lansing, MI, 48824, USA. **Are Gobies the New but Benthic Alewives in Lake Huron?**

While direct estimates of goby abundance from bottom trawls are not reliable, indirect estimates of goby biomass on average is comparable to abundant alewives prior to the alewife collapse at 2003. Are gobies the new alewives supporting Lake Huron fisheries? Indeed, the relative contribution of round gobies to piscivore diets has substantially increased. We used the time-series of lake trout diets to illustrate timeline and benchmarks of the food-web changes. We also compared indices of growth and condition, and estimates of abundance for Chinook salmon, walleye, and lake trout, against changes in abundance of alewives and rainbow smelt, and changes in goby contribution to piscivore diets. We found that 1) current piscivore biomass are largely supported by feeding on gobies, but 2) changes in growth, condition, and recruitment of Chinook salmon, walleye, and lake trout are explained by changes in the alewife and rainbow smelt abundance. While walleye and lake trout growth and condition have declined, increases in wild recruitment have allowed increases in walleye and lake trout biomass. Chinook salmon growth and condition has also shown recovery but population density has stayed low. We conclude that gobies are not new alewives, and changes in the fish community reflect relative success in recruitment among fish species. *Keywords: Round bobies, Food web, Lake Huron.*

HEBEBRAND, K.M. and BOSSENBROEK, J.M., University of Toledo, 2801 W Bancroft St, Toledo, OH, 43606, USA. **Potential Spread of Hydrilla (Hydrilla verticillata) in the Great Lakes Basin.**

Hydrilla (Hydrilla verticillata), an aquatic invasive plant, threatens to invade the Great Lakes basin. Hydrilla creates dense webs that choke out native vegetation, reduces flow in canals, clogs intakes, and interferes with navigation of watercrafts. Recreational boating has acted as a primary vector of spread for other aquatic invasive species and is expected to be a primary vector for hydrilla spread as well. The goal of this project is to predict spread of hydrilla via recreational boating to Great Lakes Basin using a gravity model. The model uses boater registration, hydrilla occurrence data, waterbody data, road data, and watershed data to predict which water bodies will attract recreational boaters. We parameterized our model based on the historical distribution of hydrilla. Based on 2015 distribution of hydrilla the model predicts the spread of hydrilla for the next 10 years in the continental United States. We expect the area of hydrilla infestation to increase by approximately 4% in next 10 years. The results of this model will contribute to a larger risk assessment and help prioritize management efforts. *Keywords: Invasive species, Hydrilla, Great Lakes basin, Modeling.*

HEER, T., WELLS, M.G., and MANDRAK, N.E., University of Toronto Scarborough, 1265 Military Trail, Toronto, ON, M1C 1A4, CANADA. **Preliminary Assessment of Asian Carp Spawning Potential in Canadian Tributaries to Lake Ontario.**

Due to the potential for an Asian carp invasion in the Great Lakes, prevention efforts (e.g. early detection, rapid response) require the knowledge of where carps are likely to spawn. In 2015, six diploid and three triploid Grass Carp were caught in Lake Ontario in the Toronto area. A preliminary assessment was completed to predict the suitability of nine Toronto-area tributaries for Asian carp spawning, using data from 2009 to 2014. The assessment estimates the time to maturity, time of year of potential spawning, and the stream length required for successful spawning using daily velocity and temperature data. The results of this assessment show high inter-annual variability in suitability. On average, only one tributary is suitable; however, in 2012, most of the tributaries were suitable due to higher water temperatures and a high-flow event that could have triggered spawning. This assessment uses more comprehensive spatial and temporal data than previous studies, and highlights substantial inter-annual variation in suitability for Asian Carp spawning. The results of this preliminary screening can be used to identify tributaries that require detailed assessment using more rigorous models. *Keywords: Lake Ontario, Invasive species, Tributaries.*

HEGNA, J.R.[1], SCRIBNER, K.T.[1], and BAKER, E.A.[2], [1]Michigan State University, Department of Fisheries and Wildlife, 480 Wilson Road, 13 Natl Res Bldg, East Lansing, MI, 48824, USA; [2]Michigan Department of Natural Resources, Marquette Fisheries Research Station, 488 Cherry Creek Rd, Marquette, MI, 49855, USA. **Juvenile lake sturgeon downstream passage and survival at two hydroelectric dams.**

Reconnecting lake sturgeon (*Acipenser fulvescens*) populations and rivers through the design and use of passage systems at hydroelectric dams is seen as a vital step toward recovery of the species. However, downstream passage behavior and survival of juvenile lake sturgeon at hydroelectric dams is poorly understood. We used stream-wide RFID antennas and the juvenile salmonid acoustic telemetry system to monitor passage behavior and route-specific survival through two hydroelectric dams on the Black River, Michigan over three years. A total of 62 age-2, 114 age-1, and 792 age-0 lake sturgeon were stocked above Tower Dam, while a total of 60 age-2, 118 age-1, and 817 age-0 lake sturgeon were stocked above Kleber Dam. A total of 25 age-2, 45 age-1, and 198 age-0 lake sturgeon were stocked below both dams to serve as control groups. We will discuss the preliminary results of this ongoing project, including route specific survival estimates for spillways, Kaplan turbines, and type-z vertical shaft turbines. We will also discuss fish screen mortality rates, forebay residency time, reservoir residency time, river residency time, and spatial movement characteristics. The results of this research will be of interest to hydroelectric companies an regulatory and natural resource agencies. *Keywords: Lake sturgeon, Management, Hydroelectric power, Fish behavior, Fish passage, Acoustics.*

HEILERS, A.H., The Blanchard River Demonstration Farms Network, Columbus, OH, 43215, USA. **The Blanchard River Demonstration Farms Network-Conservation Partnerships and Information Transfer.**

Utilizing funding made available from the U.S. EPA through the Great Lakes Restoration Initiative (GLRI), the USDA NRCS entered into a partnership agreement with the Ohio Farm Bureau Federation to establish a Demonstration Farm Network in Ohio. The purpose of the farms is to demonstrate the best, leading-edge conservation practices to reduce phosphorus and sediment entering Maumee Bay on Lake Erie. The network will publicly highlight the most effective combination of conservation practices producers can implement in the western Lake Erie Basin. Utilizing the right combination of traditional conservation practices and new technologies the network will be able to produce viable, sustainable economic and environmental results. The challenges and benefits encountered in establishing the conservation partnerships needed to develop the demonstration farm networks and information dissemination strategies will be highlighted during this session. *Keywords: Conservation, Agriculture, Nutrients, Water quality.*

HEIN, M.C. and COOPER, M.J., Northland College, Ellis AVE, Ashland, WI, 54806, USA. **Untangling drivers of chlorophyll *a* in Great Lakes coastal wetlands.**

Great Lakes coastal wetlands provide ecological services for terrestrial and aquatic life alike, providing breeding, nursery, and foraging habitat for fish and wildlife while storing flood waters and filtering runoff from the landscape. Water chemistry and chlorophyll *a* data were collected from 580 wetlands across the basin by the Great Lakes Coastal Wetlands Monitoring Program from 2011 to 2015. We identified relationships between chlorophyll *a*, various nutrients, and surrounding land use in an effort to build a predictive model of phytoplankton abundance in these systems. High concentrations of chlorophyll *a* were commonly found in wetlands with concentrations of SRP and nitrate that were at or below analytical detection limits, suggesting SRP and nitrate are quickly assimilated by phytoplankton in Great Lakes coastal wetlands. Because the availability of reactive nitrogen has been found to limit algal growth in these wetlands, the concentration of dissolved nitrogen may regulate algal productivity when other nutrients are in adequate supply. This research will aid in predicting algal growth in Great Lakes coastal wetlands, which likely has implications for understanding coastal wetland foodwebs as well as managing nutrient loading to Great Lakes coastal ecosystems. *Keywords: Coastal wetlands, Algae, Nutrients.*

HENDRICKS, A.H. and URBAN, N.R., Michigan Technological University, 1400 Townsend Drive, Houghton, MI, 49931, USA. **Model Validation as A Critical Component for the Management of Mercury Contamination in Lakes.**

Fish consumption advisories have been set for the Great Lakes and state-wide for all inland Michigan lakes due to high mercury (Hg) levels. Many lakes do not have specific advisories due to lack of measurements. In lieu of measurements, model predicted concentrations could be used. Several Hg models that have been published have not been well validated, and the uncertainty in predictions is unknown. Validation is a critical assessment because models are often over-parameterized, constrained by few measurements, and not generalized for all lakes. In this project, a mathematical model that incorporates seasonality and predicts concentrations of three Hg species (elemental, divalent, and methyl) in the water column and sediments was developed. Model validation consisted of calibration, sensitivity analysis, and uncertainty analysis. The Markov Chain Monte Carlo (MCMC) Bayesian method was used for the uncertainty analysis. This approach consists of compiling model parameter values cited in literature, and using this "prior" information to estimate what the posterior distribution is of the model parameters. This validation approach allows regulators to make more informed and confident decisions when using models in water quality management, because the range of uncertainty in model predictions is known. *Keywords: Mercury, Bayesian Statistics, Methylmercury, Modeling.*

HEPDITCH, S.L., WILKIE, M.P., and WILSON, J.M., Wilfrid Laurier University, 75 University Avenue West, Waterloo, ON, N2L3C5, CANADA. **The influence of water chemistry on the uptake of the lampricide TFM by lake sturgeon.**

Application of the lampricide 3-trifluomethyl-4-nitrophenol (TFM) to control the invasive sea lamprey (*Petromyzon marines*) within the Laurentian Great Lakes seldom causes non-target mortality. However, juvenile lake sturgeon (*Acipenser fulvivens*) are vulnerable to TFM-induced mortality, particularly when smaller than 10cm. Moreover, they are believed to be more susceptible to TFM toxicity in waters of higher alkalinity, contrasting the decrease in toxicity observed in sea lamprey and teleost fishes. The rationale behind their sensitivity to TFM has not been elucidated and lake sturgeon populations are currently reduced in the Great Lakes, where populations are 1-2% of their historic levels. There is therefore a need to understand why juvenile lake sturgeon are more sensitive to TFM, and how this is influenced by water chemistry. This research project will look at the uptake of TFM for juvenile sturgeon, and analyze ion-regulating proteins in their gills. Understanding the rationale behind the observed sensitivity of juvenile lake sturgeon to TFM could provide alterations to current lampricide application methods within the Great Lakes water basin, which would better protect this sensitive non-target species from TFM toxicity, without compromising the efficiency of sea lamprey treatments. *Keywords: Great Lakes basin, Threatened species, Invasive species, Pesticides.*

HEPPELL, S.A.[1], EVANS, A.N.[1], ZAJICEK, J.L.[2], RILEY, S.C.[3], RICHTER, C.A.[2], RINCHARD, J.[4], KRUEGER, C.C.[5], and TILLITT, D.E.[2], [1]Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR, 97331, USA; [2]U.S. Geological Survey, Columbia Environmental Research Center, Columbia, MO, 65201, USA; [3]U.S. Geological Survey, Great Lakes Science Center, Ann Arbor, MI, 48105, USA; [4]Department of Environmental Science and Biology, The College at Brockport - SUNY, Brockport, NY, 14420, USA; [5]Center for Systems Integration and Sustainability, Michigan State University, East Lansing, MI, 48823, USA. **Thiaminase activity of planktivorous fish in the Great Lakes is unrelated to their diet.**

Thiamine Deficiency Complex, a vitamin B1 deficiency that affects survival of salmonid embryos, is caused by adult salmonids' ingestion of fishes containing high levels of thiaminase. The source of thiaminase in Great Lakes food webs is unknown. We described thiaminase activity in 14 fish species and its relationship to capture depth, season, and location. We directly tested the hypothesis that thiaminase activity in prey fishes is related to their diet by comparing two metrics of diet (stomach contents and fatty acid profiles) to thiaminase activity. The goal of this analysis was to identify prey taxa in the diet of fishes that are consistently abundant in fishes with high thiaminase activity and consistently absent or at

low abundance in fishes with low thiaminase activity. We found no compelling evidence that the thiaminase activity of fish viscera was related to any specific component of the diet. Our analysis suggested *Bythotrephes* as a potential candidate source of thiaminase, but this taxon was not consistently present in the diet of thiaminase-containing fishes. Saturated fatty acids (12:0, 17:0, and 18:0) and 20:4n-6 were associated with fishes containing high thiaminase activity, suggesting that thiaminase activity was more likely to occur in pelagically feeding than benthically feeding fishes. *Keywords: Vitamin B, Thiaminase, Fish.*

HERMAN, M.R.[1], NEJADHASHEMI, A.P.[1], DANESHVAR, F.[1], ROSS, D.M.[2], WOZNICKI, S.A.[1], ZHANG, Z.[3], and ESFAHANIAN, A.H.[2], [1]Department of Biosystems and Agricultural Engineering, Michigan State University, 225 Farrall Hall, East Lansing, MI, 48824, USA; [2]Department of Computer Science and Engineering, Michigan State University, 428 South Shaw Lane, East Lansing, MI, 48824, USA; [3]Physical Sciences Division, Department of Statistics, University of Chicago, 5640 S. Ellis Avenue, Chicago, IL, 60637, USA. **Stream Health Based Optimization of Best Management Practice Implementation.**

Freshwater is a vital resource and thus it is necessary to insure the sustainability of freshwater ecosystems for present and future generations. This study introduces an approach that can guide the implementation of best management practices (BMPs) within a watershed, while improving stream health. To accomplish this, an optimization system was developed by coupling series of models including the Soil Water Assessment Tool, the Hydrologic Index Tool, and an ANFIS (adaptive neuro fuzzy inference system)-based stream health predictive model. This optimization system was utilized a genetic algorithm that maximized the watershed-level stream health score by implementing five agricultural BMPs throughout the Honeyoey Creek-Pine Creek Watershed in Michigan. Finally, an economic analysis was performed to identify, which scenario improved stream health at the lowest cost. The final selected scenario showed an overall improvement in stream health condition after implementing the scenario suggested by the optimization system. This approach can be adapted by stakeholders, allowing for the development of cost effective water quality management plans that also improve stream health conditions. *Keywords: Biological integrity, SWAT, Genetic algorithm.*

HEUVEL, C.E.[1], HAFFNER, G.D.[1], YINGMING, Z.[2], and FISK, A.T.[1], [1]GLIER - University of Windsor, 401 Sunset Avenue, Windsor, ON, N9B 3P4, CANADA; [2]Lake Erie Management Unit OMNRF, 320 Milo Rd, Wheatley, ON, N0P 2P0, CANADA. **March to the beat of your own Drum: Ontogenetic variation in niche & diet in three Lake Erie fishes.**

The feeding ecology of fishes often vary with ontogeny, in particular for predators that tend to increase in trophic position with size. As such, ontogeny needs to be considered when assessing trophic transfer of energy and biomass through food webs. Although the feeding ecology and ontogeny of top predators has been studied, middle and lower trophic level species have often been overlooked despite their large contributions to biomass within aquatic food webs. Here, we quantified isotopic niche and diet of three species at different trophic levels (lower: Freshwater Drum, middle: White Perch, upper: Walleye) in Lake Erie using stable isotopes of nitrogen (δ15N), carbon (δ13C), and sulfur (δ34S). We predicted that isotopic niche would correlate most at small size classes (<200mm TL) and diverge at medium (200-400mm) and large (>400mm) size classes. Unexpectedly, small fishes experienced isotopically distinct niches, whereas the niches of medium fish converged before diverging again at lengths >400mm. Drum exhibited distinct changes in niche at different size classes, whereas Walleye and Perch showed few if any distinct changes in niche with length. This suggests understanding how niche relates to diet and trophic position is crucial to understanding the influence of ontogeny on food web structure in a large, productive lake. *Keywords: Fish, Lake Erie, Niches.*

HEWITT, B.A.[1], LOPEZ, L.S.[1], MAGNUSON, J.J.[2], and SHARMA, S.[1], [1]York University, 4700 Keele Street, Toronto, ON, M3J 1P3, CANADA; [2]Center for Limnology, 680 North Park Street, Madison, WI, 53706-1413, USA. **Effects of Climate Change on Lake Ice Freeze Up on Lakes Across the Northern Hemisphere.**

Throughout the last century, Northern Hemisphere lake ice freeze up has become later with increasing rates over the last few decades. Our study examines how climate-induced changes on lake ice freeze up will influence ecosystem structure of 74 lakes across the Northern Hemisphere. We collated lake ice freeze up dates from 1950-2014 from the National Snow and Ice Data Center, as well as updated ice freeze up records from collaborators. We obtained monthly air temperature, precipitation, and cloud cover data from the University of East Anglia Climatic Research Unit and large-scale climate drivers from various open source databases online. We found that lakes across the Northern Hemisphere froze 1.6 days per decade later (2 days per decade earlier to 3.7 days per decade later) over the last 65 years. Since 1950, we found that lakes froze 10 days later on average. Air temperatures, precipitation, cloud cover, and large-scale climate drivers explained the advancement of freeze up dates in lakes across the Northern Hemisphere. One third of our lakes experienced a breakpoint with higher rates of warming following a significant El Nino event in 1986, 1991, and 1997. These shifts in lake ice phenology suggest significant climate warming in lakes since 1950 and suggest the prospect of less ice cover in lakes under future climate change. *Keywords: Climate change, Freeze up, Ice, Northern Hemisphere, Modeling.*

HILL, B., DOVE, A., and BACKUS, S., Environment & Climate Change Canada, Burlington, CANADA. **Trends in Niagara River Nutrient Concentrations & Loadings: 1975 - 2015.**

Identification of nutrient imbalance and the resurgence of nuisance algae in the Laurentian Great Lakes has lead to the recognition of significant gaps in water quality information. More specifically, the Lake Ontario Nutrient Targets Task Team struck in support of the Great Lakes Water Quality Agreement Annex 4 (Nutrients) has identified the need for long-term data to develop nutrient targets for Lake Ontario and to better predict the impacts of nutrient load reduction efforts in Lake Erie to Lake Ontario. As the single largest inflow to Lake Ontario, it follows that the Niagara River is a major source of nutrients. Environment and Climate Change Canada has been operating upstream and downstream water quality monitoring, including nutrients and major ions, on the Niagara River since 1975. The status and trends for Niagara River nutrients at Fort Erie and Niagara-on-the-Lake from 1975 to 2015 are presented along with an examination of the methods used for sample collection and analysis. *Keywords: Water quality, Nutrients, Niagara River.*

HILLIARD, K.[1], STOTT, W.[1], and KOCOVSKY, P.M.[2], [1]Great Lakes Science Center-USGS, 1451 Green Rd., Ann Arbor, MI, 48105, USA; [2]USGS Lake Erie Biological Station, 6100 Columbus Ave., Sandusky, OH, 44870, USA. **Development of a TaqMan assay for the identification of Silver Chub in larval catch samples.**

Silver chub *Macrhybopsis storeriana* is the largest native cyprinid in Lake Erie and is listed as endangered under COSEWIC. This population is unique in that it is the only known lake-dwelling population of this riverine species. An information gap for developing a recovery plan is spawning locations. Spawning in large Lake Erie tributaries is suspected, but to date sampling in the Detroit, Maumee, and Sandusky Rivers has failed to produce larvae. In order to protect the silver chub from further declines in population size, an effective method must be in place to identify larval samples and possibly detect the presence of silver chub in environmental samples. In this project a TaqMan assay was developed for the identification of silver chub among large collections of other species. Mitochondrial DNA sequences for common Lake Erie fish species were retrieved from GenBank and used to identify diagnostic single-nucleotide polymorphisms. Primers and probes were then developed for use in real time PCR. The assay was tested to gauge its discriminatory ability among fish species of the region and its ability to identify silver chub in mixed samples of larvae. *Keywords: Silver chub, Larval species identification, Real time PCR.*

HILLIS, E.L.[1], MCLEOD, A.M.[3], XENOPOULOS, M.A.[2], and HAFFNER, G.D.[1], [1]University of Windsor- GLIER, Windsor, ON, CANADA; [2]Trent University, Peterborough, ON, CANADA; [3]Memorial University of Newfoundland, St. John's, NL, CANADA. **Factors Regulating Primary Production in the Western Basin of Lake Erie.**

Eutrophication is a serious threat in the western basin of Lake Erie. In the 1960s, target total phosphorus loadings were met by the 1980s, corresponding with a decrease in chlorophyll *a* (chl *a*) and phytoplankton biomass. However, primary production was not consistently measured over this time. Since the mid-1990s, the reappearance of harmful algal blooms (HABs) has led to further questions regarding the drivers of these blooms. In the summer of 2014 and 2015, primary production, chl *a* and biomass were measured at a nearshore and offshore site in the western basin of Lake Erie. When compared to historical studies, chl *a* decreased significantly from an average of 12.6 mg/m^3 in 1970 to 3.6 mg/m^3 in 2015, while primary production and biomass did not significantly change over the same period (annual averages ranged from 26.5 to 25.6 mgC/m^3/h for primary production and 3.5 to 1.6 g/m^3 for biomass). Generalized linear models (GLMs) found that while depth, water temperature and chl *a* were always included as regulating factors of primary production in 2014 and 2015, total phosphorus concentrations were never included. This suggests that other factors besides total phosphorus must be considered as potential regulators of primary production. *Keywords: Eutrophication, Productivity, Lake Erie.*

HINCHEY, E.K.[1], KLEI, A.J.[2], AXNESS, K.[3], O'DONNELL, T.K.[1], and PERERCONE, J.[1], [1]U.S. EPA Great Lakes National Program Office, 77 W. Jackosn Blvd., Chicago, IL, 60604, USA; [2]Ohio EPA, P.O. Box 1049, Columbus, OH, 43216-1049, USA; [3]Wisconsin Department of Natural Resources, 1155 Pilgrim Road, Plymouth, WI, 53073, USA. **Challenges and approaches to removing the Eutrophication or Undesirable Algae BUI.**

The Great Lakes Restoration Initiative is advancing clean-up and restoring beneficial uses in Areas of Concern, with 68 BUIs out of 255 removed by end of 2016. The Eutrophication or Undesirable Algae BUI was identified at 19 U.S. AOCs with persistent water quality problems attributed to excessive nutrient discharges from point or nonpoint sources. Typically, the impairment manifests itself as nuisance or harmful algal blooms, dissolved oxygen depletion in bottom waters, and decreased water clarity. This presentation will provide an overview of the Eutrophication BUI history and status across the AOCs and compare criteria used to remove the BUI. We also examine reasons why this BUI is often difficult to remove, and will highlight guidance and targets currently being used in Michigan and Ohio to address this challenging BUI. *Keywords: Eutrophication, AOC, Cleanup, BUI, Great Lakes Restoration Initiative (GLRI).*

HINDERER, J.L.M.[1], ADAMS, J.V.[2], BENNION, D.H.[3], JUBAR, A.K.[4], NEAVE, F.B.[5], FAUST, M.D.[6], and SIEFKES, M.J.[1], [1]Great Lakes Fishery Commission, 2100 Commonwealth Blvd., Suite 100, Ann Arbor, MI, 48105, USA; [2]U.S. Geological Survey, Great Lakes Science Center, 223 East Steinfest Road, Antigo, WI, 54409, USA; [3]U.S. Geological Survey, Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105, USA; [4]U.S. Fish and Wildlife Service, Ludington Biological Station, Ludington, MI, 49431, USA; [5]Fisheries and Oceans Canada, Sea Lamprey Control Centre, 1219 Queen Street East, Sault Ste. Marie, ON, P6A 2E5, CANADA; [6]Ohio Department of Natural Resources, Sandusky Fisheries Research Station, 305 East Shoreline Drive, Sandusky, OH, 44870, USA. **Water Quality, Habitat Restoration, and Invasive Sea Lamprey in the St. Clair River.**

A large population of larval sea lampreys was recently detected in the St. Clair River, which in the past was thought too polluted to support this species. Remediation and restoration have led to improved water and habitat quality in the system. We examined the relationship between water quality trends in the St. Clair River and larval sea lamprey populations, using existing monitoring data from multiple agencies. An inability to combine data across agencies limited the spatial and temporal coverage of our water quality data. We also created Geographic Information System layers of habitat restoration sites, sediment remediation areas, former combined sewer overflow sites, and former industrial point source pollution discharges and overlaid these "areas of remediation" with hot spots of elevated larval sea lamprey density. Although our data did not allow a definitive answer to the question of whether habitat restoration and improved water quality have led to increases in larval sea lampreys in the St. Clair River, other formerly polluted river systems may produce more sea lampreys as they are restored. Agencies working in such systems, including connecting channels, must institute consistent, well-designed water quality monitoring programs to understand how undesirable species might respond to changing conditions.
Keywords: St. Clair River, Sea lamprey, Invasive species, Water quality.

HIRSCH, R.M.[1] and CHOQUETTE, A.F.[2], [1]U.S. Geological Survey, 12201 Sunrise Valley Drive, Reston, VA, 20192, USA; [2]U.S. Geological Survey, 640 Grassmere Park Drive, Nashville, TN, 37211, USA. **Weighted Regressions for Evaluating Progress in Nutrient Reduction in Western Lake Erie Tributaries.**

Evaluating the evolving behavior of Great Lakes' tributaries as they deliver nutrients downstream is a complex task. These evaluations rely heavily on analysis of historical records for both nutrient concentrations and river discharge. The statistical tools used must therefore consider the following complexities: 1) the relation between concentration and discharge which can vary across seasons, 2) seasonal concentration-discharge relationships

that may change over time, 3) often high inter-annual variability in nutrient delivery due to natural climatic fluctuations, 4) potential multi-decadal trends in the frequency distribution of river discharge, driven by some combination of climate trends and trends in the response of runoff to precipitation, and 5) the presence of non-monotonic nutrient flux trend patterns. Weighted Regressions on Time, Discharge, and Season (WRTDS) is a statistical method devised to overcome these complications, in order to present a clearer picture of the nature and extent of river flux changes at time scales of a decade or more. The application of WRTDS to 1985-2015 nutrient datasets for western Lake Erie tributaries provides new insights into the ongoing changes in the delivery of soluble-reactive phosphorus and other nutrients to Lake Erie, as well as the change-drivers. *Keywords: Nutrients, Trends, Modeling, Lake Erie.*

HLEVCA, B. and WELLS, M.G., University of Toronto, 1265 Military Trail, Toronto, ON, M1C 1A4, CANADA. **Observations and Numerical Modeling of the Exchange Flows between Toronto Harbour and Lake Ontario.**

Field studies conducted in the ice-free periods of 2013 and 2016 investigated exchange flows between the Toronto Harbour system of embayments and Lake Ontario. Prevailing westerly wind during the summer months caused frequent upwellings in North Western Lake Ontario. The water depth in Toronto Harbour is too shallow and mass exchange with the lake too efficient to allow extended thermal stratification. Consequently, differential density currents are generally too weak to have a significant contribution to the exchange. A calibrated depth-integrated hydrodynamic transport model is used to show that significant exchange takes place due to the amplified seiche mode with period of 1 hour and that the exchange rate is several times greater than when only wind driven surface currents forcing is considered. The exchange is also shown to depend on the vegetation development. A 3-D model illustrates the dramatic effect of the oscillating inflow from Lake Ontario on the temperatures of the harbour. The hydrodynamic and temperature transport models are validated by extensive field observations taken in 2013 and 5 additional ADCPs in 2016. The volume of the exchange was estimated to be ~10% of the harbour volume per day (40-50 m^3s^{-1}). During sustained upwelling periods, the exchange was slightly larger. *Keywords: Lake Ontario, Exchange flows, Hydrodynamic model, Barotropic forcing, Coastal processes, Toronto Harbour.*

HOBRLA, R.M.[1] and EBERHARDT, R.[2], [1]Michigan Office of the Great Lakes, Lansing, MI, USA; [2]Michigan Office if the Great Lakes, retired, Lansing, MI, USA. **Michigan Approach to Targets for Removing BUIs and Delisting AOCs.**

Michigan is the Great Lakes State. As such, it plays a major role in the Areas of Concern (AOC) program under the Great Lakes Water Quality Agreement. With its original

14 AOCs, Michigan contains almost half of the AOCs and accounts for nearly 45% of the cumulative Beneficial Use Impairments (BUIs) on the U.S. side of the border. Michigan is the only state dealing with both binational and bi-state AOCs. Approximately ten years ago Michigan significantly changed its approach to the AOC program by specifically targeting individual BUIs rather than simultaneously dealing with all BUIs in each AOC. As part of this approach, Michigan developed guidance for delisting AOCs that suggested statewide standards for the removal of BUIs. The approach encouraged local Public Advisory Councils to adopt these statewide targets while allowing them the flexibility to propose site specific criteria if appropriate. Utilizing this new approach has resulted in significant progress in Michigan's AOC program with two of the originally fourteen AOCs formally delisted, an additional three AOCs with all management actions completed, and approximately one third of Michigan's original BUIs removed. *Keywords: AOCs, BUIs, Delisting.*

HOFFMAN, D.K.[1], MCCARTHY, M.J.[1], DAVIS, T.W.[2], GOSSIAUX, D.C.[2], BURTNER, A.M.[3], JOHENGEN, T.H.[3], PALLADINO, D.A.[3], GARDNER, W.S.[4], MYERS, J.A.[1], and NEWELL, S.E.[1], [1]Wright State University, 3640 Colonel Glenn Hwy, Dayton, OH, 45435, USA; [2]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, USA; [3]University of Michigan Cooperative Institute for Limnology and Ecosystems Research, Ann Arbor, MI, USA; [4]The University of Texas Marine Science Institute, Port Aransas, TX, USA. **Water Column Ammonium Dynamics Affecting Harmful Cyanobacterial Blooms in Lake Erie.**

Cyanobacterial harmful algal blooms (HABs) in western Lake Erie are largely driven by agricultural nitrogen (N) and phosphorus from the Maumee River watershed. Cyanobacterial dominance and HAB development may depend on ammonium availability, and increased ammonium has been linked to toxin production. ^{15}N tracers were used to quantify rates of ammonium regeneration and potential uptake, ammonia oxidation to nitrite (the first step of nitrification), and total nitrification. In 2015, ammonia oxidation and total nitrification rates were comparable to coastal ocean rates. However, nitrification rates were an order of magnitude lower than total community ammonium uptake rates, indicating that ammonia oxidation and nitrification are not the dominant uptake pathways. During non-bloom months, regeneration rates could account for approximately 80% of potential community uptake, but during the height of the bloom, when community ammonium demand was much greater, regeneration could only support 44% of potential uptake. These results suggest that management of external total N loads, which are readily converted to ammonium, may be necessary to reduce bloom biomass and toxicity. *Keywords: Biogeochemistry, Nutrients, Harmful algal blooms.*

HOFFMAN, J.C. and WILLIAMS, K., US EPA Office of Research and Development, 6201 Congdon Blvd, Duluth, MN, 55804, USA. **Remediation to Restoration to Revitalization - A Path Forward for AOCs?**

Great Lakes Areas of Concerns (AOCs) have remediation and restoration goals that are defined by the status of Beneficial Use Impairments (BUI), which conceptually are analogous to ecosystem services (i.e., benefits from nature). For AOC communities to better realize the benefits of sediment remediation and habitat restoration, however, we need to determine which ecosystem services are affected and characterize the steps between improving environmental quality, changing ecosystem services (e.g., increasing recreational or cultural value), and revitalizing urban waterfront neighborhoods. To address these questions, we initiated a conversation at the US EPA's Annual AOC meeting in 2016 with community members and advisers who are committed to the AOC program. Participants recognized recent improvement in a variety of ecosystem services; increased recreational use was widely observed, especially kayaking and new trails. Recreational users are becoming an important social indicator of the health and value of these resources. Further, we found that local leadership and planning is the most significant factor affecting changes on land. We conclude that to enhance public benefits from AOC projects, it is important to discuss these waterways both in terms of water quality targets and as a valued resource from which people benefit. *Keywords: Remediation, Ecosystem services, Great Lakes Restoration Initiative (GLRI), Communities, Management.*

HOLBROOK, C.M.[1], HONDORP, D.W.[2], COLBORNE, S.F.[3], THOMPSON, H.T.[1], FISK, A.T.[3], and KRUEGER, C.C.[4], [1]U. S. Geological Survey, Hammond Bay Biological Station, 11188 Ray Rd., Millersburg, MI, 49759, USA; [2]U. S. Geological Survey, Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105, USA; [3]University of Windsor, Great Lakes Institute for Environmental Research, 2601 Union Street, Windsor, ON, N9B 3P4, CANADA; [4]Michigan State University, Center for Systems Integration and Sustainability, 1405 South Harrison Road, 115 Manly Miles Building, East Lansing, MI, 48823, USA. **A Passively Transported Receiver System to Improve Spatial Monitoring of Telemetry-Tagged Fishes.**

Telemetry represents a popular and increasingly useful toolset for aquatic animal ecology, management, and conservation. However, the spatial resolution of monitoring with stationary telemetry receivers (the most common method) is limited by the number of receivers that can be purchased and maintained. To overcome this limitation, we developed and tested a passively transported telemetry system, comprised of small floating vessels (drifters) equipped with GPS (smartphone) and telemetry receivers, to describe locations of six species of acoustic-tagged fishes in the St. Clair and Detroit Rivers. Specifically, we (1)

compared Lake Sturgeon and Sea Lamprey distribution and movement data collected with passive drifters to data collected over the same time period with the fixed receiver network (i.e., evaluated the space-time tradeoff) and (2) used data from passive drifters to estimate detection range and efficiency of fixed-station receivers. We also more broadly examined the advantages, disadvantages, and synergies of passive mobile and stationary telemetry platforms in describing spatial distribution and behavior of fishes. Results advance understanding of mobile telemetry methods and could contribute to improved design of telemetry studies, particularly for applications that require sampling over large areas.
Keywords: Fish populations, Fish tagging, Spatial distribution.

HOLDA, T.J., WATKINS, J.M., and RUDSTAM, L.G., Cornell Biological Field Station, 900 Shackelton Point Rd., Bridgeport, NY, 13030, USA. **Seasonal and spatial patterns in Mysis diluviana in Southern Lake Michigan during 2015.**

Mysis diluviana is an abundant offshore crustacean in the Great Lakes. The species is common in diets of offshore fish populations in Lake Michigan, and is known to consume both phytoplankton and zooplankton in that lake. During May, July, and September of the 2015 CSMI year, we collected 28 samples of Mysis diluviana from 11 stations in southern Lake Michigan. We report seasonal trends in abundance, size structure, demographics, fecundity, and spatial distribution. Mysids were more abundant in the eastern than the western part of the southern basin. Female mysids grew quicker than male mysids, and achieved larger maximum size. Prevalence of adults that were reproductively mature was an order of magnitude higher in May than in July. We compare our findings to previous findings from Lake Michigan, and to findings from Lake Ontario during 2013.
Keywords: Growth, Reproduction.

HOLDEN, J.P.[1], CONNERTON, M.[2], WEIDEL, B.C.[3], and HOYLE, J.A.[1], [1]OMNRF, Glenora, ON, CANADA; [2]NYSDEC, Cape Vincent, NY, USA; [3]USGS, Oswego, NY, USA. **How Many Cisco are in Lake Ontario: Scaling Up Acoustics and Midwater Trawl Data.**

Trends in Cisco (Lake Herring, *Coregonus artedi*) abundance in Lake Ontario are derived from multiple fish community assessment programs although few of these programs were designed to specifically target Cisco. Multiple assessment programs have shown modest increases in Cisco abundance in recent years generating interest in developing a lake-wide assessment program that would assess abundance and distribution. In 2016, targeted midwater trawling and acoustic assessment was conducted in conjunction with a long term acoustic survey to evaluate survey methodology that could be used to provide whole-lake estimates of distribution and abundance for Cisco. *Keywords: Spatial distribution, Coregonus, Hydroacoustics, Midwater trawl, Cisco.*

HOLEM, R.R., GEI Consultants, 230 North Washington Square, Lansing, MI, 48933, USA. **Saginaw Bay Walleye Regulation Changes and Potential Impact on Exposure to Fish Contaminants.**

Fish are an important and high-quality food source, yet fish consumption is also a primary route of human exposure to contaminants. Thus, changes to fishing regulations such as fish minimum and maximum size limits and bag limits could influence exposure to fish contaminants. In October 2015, the Michigan Natural Resource Commission approved changes to walleye harvest regulations for Lake Huron management Unit MH-4, which includes the Saginaw Bay and a portion of the Saginaw River. The changes resulted in a decrease in the walleye minimum size limit (15" to 13") and an increase in the daily possession limit (from five to eight walleye) for anglers fishing those waters. Fish consumption advisories are currently in place for many species of fish harvested from the Saginaw Bay and River, including walleye. Walleye creel survey and fish contaminant data for Lake Huron management Unit MH-4 will be assessed to evaluate the extent to which the new regulations could influence potential exposure of consumers to fish contaminants. This information may be useful to fisheries managers as well as risk assessors and public health officials. *Keywords: Human health, Fish consumption advisories, Fishing, Saginaw Bay, Walleye.*

HOLLENHORST, T.P., BROWN, T.N., MCKINNEY, P.J., MILLER, S.E., COTTER, A., SCHAROLD, J.V., TREBITZ, A.S., and HOFFMAN, J.C., EPA Mid-Continent Ecology Division, 6201 Congdon Blvd, Duluh, MN, 55804, USA. **Eutrophication Monitoring for Lake Superior's Chequamegon Bay - Before and After Large Summer Storms.**

A priority for the Lake Superior CSMI was to identify susceptible nearshore eutrophication areas. We developed an integrated sampling design to collect baseline data for Lake Superior's Chequamegon Bay to understand how nearshore physical processes and tributary loading relate to observed chlorophyll concentrations. Sampling included ship-based water samples combined with vertical CTD casts, continuous in situ towing and data collected from an autonomous underwater glider. Sampling was conducted during June, July and September. The glider collected regional data as part of three extended missions in Lake Superior over the same periods. During the study, two significant storm events impacted the western end of Lake Superior; the first occurred during July 11-12, with 8-10 inches of rain in 24hrs, and the second on July 21 with winds in excess of 161 km/h. Using GIS software, we organized these diverse temporal data sets along a continuous time line with temporally coincident Modis Satellite data to visualize surface sediment plumes in relation to water quality measurements. Preliminary results suggest that both events impacted regional water quality, and that nearshore physical forces (upwelling and currents) influenced the spatial variability. Results comparing in situ measures with remotely sensed images will be discussed. *Keywords: Water quality, Coastal processes, Lake Superior.*

HONDORP, D.W.[1] and WILLS, T.C.[2], [1]US Geological Survey-Great Lakes Science Center, 1451 Green Rd, Ann Arbor, MI, 48105, USA; [2]Michigan Department of Natural Resources-Lake St. Clair Fisheries Research Station, 33135 South River Rd, Harrison Twp, MI, 48045, USA. **A perspective on the challenges and opportunities for field sampling of Round Goby.**

The invasive round goby (*Neogobius melanostomus*) is the most recent non-native fish species to colonize and proliferate in the Great Lakes. The ability to assess changes in round goby abundance and habitat use is important for the future management of Great Lakes fish communities given evidence that several commercially- and recreationally-harvested piscivores (e.g., lake whitefish, lake trout, walleye) now feed on round goby as well as suspicion that round goby outcompete or prey upon native forage fish (e.g., sculpins). However, several aspects of goby ecology and life history complicate field sampling of round goby with conventional gears such as bottom trawls. In this presentation, we review the benefits and caveats of the different field gears used to quantitatively sample round goby and discuss how technology (or new applications of existing technology) can be used to overcome the challenges of round goby sampling. *Keywords: Round goby, Exotic species, Lake Huron.*

HÖÖK, T.O., FEINER, Z.S., FOLEY, C.J., and MALINICH, T.D., Purdue University Department of Forestry and Natural Resources, West Lafayette, IN, 47907, USA. **Meta-analysis of effects of microplastics on aquatic organisms.**

Microplastics (plastic particles less than 5 mm in size) have emerged as a global contaminant of concern in marine and freshwater ecosystems. A number of studies have documented consumption of microplastic particles by a wide variety of aquatic invertebrates and diverse ontogenetic stages of fishes. Such in situ consumption, has elevated concern that ingestion of microplastics may have deleterious effects on the health of aquatic organisms. In turn, a relatively recent proliferation of species-specific studies have quantified the effects of microplastics on factors such as mortality, growth, reproduction, and consumption of aquatic invertebrates and fishes. We performed a meta-analysis to examine patterns of lethal and non-lethal effects of microplastics across >40 laboratory experiments to ascertain relative risks for aquatic organisms associated with exposure to microplastics. In this presentation, we will outline our meta-analysis approach, summarize preliminary findings about the general effects of microplastics, and discuss implications of results, including caveats and considerations for future research. *Keywords: Microplastics, Zooplankton, Fish, Macroinvertebrates.*

HOUGHTON, E.M., NEW Water, 2231 N. Quincy Street, Green Bay, WI, 54302, USA. **Green Bay Water Quality Review: 30 Years of Monitoring.**

NEW Water, the brand of the Green Bay Metropolitan Sewerage District, has gone beyond simply treating wastewater. For the past 30 years, NEW Water has been monitoring water quality in its receiving waters consisting of the lower Fox River and Green Bay, which are designated as an Area of Concern by the IJC. NEW Water has maintained one of the longest comprehensive water quality databases on the Great Lakes through collecting water quality and sensor data and collaborating on research projects. This information has aided in the development of A Total Maximum Daily Load and Watershed Management Plan for Total Phosphorus and Total Suspended Solids in the Lower Fox River Basin and Lower Green Bay which is now beginning implementation. The lower Fox River and lower Green Bay are highly eutrophic systems. However, regions are showing signs of decreased total phosphorus and total suspended solids. While the East River shows signs of increased orthophosphorus and nitrate concentrations in recent years. These data are incredibly valuable and are now being shared through a GLOS funded website, incorporated into AOC reviews and projects, included in new biogechemical predictive models for Green Bay, and helping to better understand the links between the watershed and these impaired water bodies. *Keywords: Monitoring, Green Bay, Nutrients.*

HOUSE, N.[1], MINIHKEIM, S.[1], WALSH, M.G.[2], and HELLQUIST, C.E.[1], [1]Dept. Biological Sciences, State Univ. of New York Oswego, 7060 State Route 104, Oswego, NY, 13126, USA; [2]United States Geological Survey, Great Lakes Science Center, Lake Ontario Biological Station, Oswego, NY, 13126, USA. **The Abundance of Microplastics in Forage Fish of Lake Ontario.**

Microplastics are becoming more widely recognized as pollutants in the Great Lakes. To date, we have sampled Round Goby (benthic, n=73), Deepwater Sculpin (benthic, n=14), Slimy Sculpin (benthic, n=18), and Alewife (pelagic, n=95) from 13 locations throughout Lake Ontario (depth 6-125 m). Digestive tracts were dissolved in KOH to isolate microplastics. Plastics were highly prevalent in all samples (99% occurrence). Fibers were the most abundant plastic recovered (81%), followed by fragments (16%), and large spheres (3%). For Round Goby, Deepwater Sculpin, Slimy Sculpin, and Alewife, respectively, we recovered 3.8, 1.9, 7.1, and 3.7 fibers and 1.04, 0.07, 0.44, and 0.7 fragments per fish. No large spheres were found in Round Goby and all other species had less than 0.5 per fish.

Round Gobies contained 37% of the total plastics recovered (36% fibers and 49% fragments). Deepwater Sculpin contained 3% of the total plastics recovered (3% fibers, 0.6% fragments, and 16% spheres). Slimy Sculpin contained 14% of the total plastics recovered (16% fibers, 5% fragments, and 6% large spheres). Lastly, 46% of total plastics were found in Alewives (45% fibers, 45% fragments, 78% large spheres). The high prevalence of plastics in forage fish diets lakewide confirms that microplastics are entering the Lake Ontario food web. *Keywords: Lake Ontario, Plastics, Fish diets, Environmental contaminants.*

HRYCIK, A.R.[1], STOCKWELL, J.D.[1], and SHAMBAUGH, A.[2], [1]University of Vermont, 3 College Street, Burlington, VT, 05401, USA; [2]Vermont Department of Environmental Conservation, 1 National Life Drive, Montpelier, VT, 05620, USA. **A comparison of FlowCam and microscopy methods for phytoplankton community assessment.**

FlowCam is a particle analysis system, and its relatively recent application to phytoplankton permits rapid identification and biovolume measurements through automated imaging and analysis. However, direct comparisons of estimates from FlowCam and standard microscopy methods using diverse phytoplankton assemblages have been limited. We processed over 100 samples collected bi-weekly from heterogeneous regions of Lake Champlain from May to October 2015. Habitats ranged from shallow, eutrophic bays to the deep, mesotrophic main lake, and the phytoplankton assemblages included cyanobacteria, chlorophytes, diatoms, chrysophytes, dinoflagellates, and cryptophytes. We measured cell densities and dimensions with both an inverted microscope and a FlowCam, and compared taxa biovolumes and community metrics such as genera richness and diversity. Results from this study inform the use of FlowCam for diverse phytoplankton communities similar to those in the Great Lakes and other large lakes. *Keywords: Phytoplankton, Lake Champlain, Monitoring.*

HU, H.[1], WANG, J.[2], LIU, H.[3], and GOES, J.[4], [1]University of Michigan, Ann Arbor, 4840 S State Rd, Ann Arbor, MI, 48108, USA; [2]NOAA/GLERL, 4840 S State Rd, Ann Arbor, MI, 48105, USA; [3]Texas A&M University, Galveston, USA; [4]Columbia University, New York, USA. **Simulation of Phytoplankton Distribution and Variation in the Bering-Chukchi Sea using a 3D Physica.**

A 3D physical-biological model has been used to simulate seasonal phytoplankton variations in the Bering-Chukchi Sea with a focus on understanding the physical and biogeochemical mechanisms involved in the formation of the Bering Sea Green Belt (GB) and the Subsurface Chlorophyll Maxima (SCM). Model results suggest that the horizontal distribution of the GB is controlled by a combination of light, temperature, and nutrients. Model results indicated that the SCM exists because of a rich supply of nutrients and sufficient light. The seasonal onset of phytoplankton blooms is controlled by different factors at different locations in the Bering Sea. In the off-shelf central region of the Bering Sea, phytoplankton blooms are regulated by available light. On the Bering Sea shelf, sea ice through its influence on light and temperature plays a key role in the formation of blooms, whereas in the Chukchi Sea, bloom formation is largely controlled by ambient seawater temperatures. A numerical experiment conducted as part of this study revealed that plankton-sinking is important for simulating the vertical distribution of phytoplankton and the seasonal formation of the SCM. An additional numerical experiment revealed that sea ice algae account for 14.3~36.9% of total phytoplankton *Keywords: Phytoplankton, Biophysical, Coupled.*

HU, Y.[1], KERKEZ, B.[1], and SCAVIA, D.[1], [1]University of Michigan, Ann Arbor, MI, USA; [2]University of Michigan, Ann Arbor, MI, USA. **Toward a high-resolution model of urban phosphorus input into the Detroit River.**

We investigated the major sources of urban phosphorus inputs into the Detroit River for 2009-2015 to quantify their temporal dynamics and characterize the patterns from all U.S. urban areas in Huron-Erie Corridor watershed. Drawing upon a wealth of measurements, as well as a rainfall runoff model, our analysis compared inputs from point sources (including wastewater treatment plants (WWTPs), combined sewer overflows (CSOs), and runoff. Initial results suggest point sources play a major role in the contribution of urban phosphorus into the Detroit River. To investigate potential reductions in urban phosphorus loads, we developed a Greater Regional Urban Model that simulates sewer and storm water flows. This model incorporates high-resolution precipitation measurements and numerous flow sensor data to predict sewer flow and CSO occurrence at finer temporal resolution. As a result, the model allows us to inform how the existing conveyance systems can be modified, potentially via real-time control, to reduce CSOs and phosphorus loads; and explore the role low impact development (e.g., green infrastructure) will play in these reductions, as well as where these solutions should be placed to maximize watershed-scale flow and phosphorus interception. *Keywords: Phosphorus, Urban areas, Modeling, Detroit River.*

HUANG, C., KUCZYNSKI, A., XUE, P., and AUER, M.T., Michigan Technological University, 1400 Townsend Drive, Houghton, MI, 49931, USA. **Hydrodynamics, Point Source Discharges and Water Quality in the Lake Ontario Nearshore.**

The focus of water quality management in the Laurentian Great Lakes has shifted to nearshore waters as reductions in whole lake pollutant levels have occurred. The Great Lakes nearshore receives tributary and point sources discharges of pollutants, but also serves as a source of drinking water; often with outfalls and intakes in close proximity. Effluent standards are met through a combination of treatment and offshore discharge (dilution) aided by ambient mixing. Treatment requirements and siting of outfalls is guided by application of hydrodynamic-water quality models that can relate the position and dimensions of the effluent plume with respect to the location of receptors (beaches, water intakes) where best uses may be impacted. Here we describe the application of a hydrodynamic model (FVCOM), in tracking plume fate and transport at a site in the Lake Ontario nearshore and coastal zone. The ability of FVCOM to simulate the distribution of a conservative substance following discharge is demonstrated through model calibration and confirmation. Key findings of the exercise relate to: (1) the spatiotemporal pattern of plume within the coastal boundary layer, (2) the role of kinetics and the water quality standard in determining the area impacted by the plume. *Keywords: Hydrodynamic model, Lake Ontario, Coastal ecosystems.*

HUBERTY, B.[1], BOURGEAU-CHAVEZ, L.L.[2], BROOKS, C.N.[2], GRIMM, A.[2], BATTAGLIA, M.J.[2], WHITE, L.[3], MURNAGHAN, K.[4], BRISCO, B.[5], MORIN, P.[6], PELLETIER, K.[7], and KLASSEN, J.[8], [1]U.S. Fish and Wildlife Service, 5600 American Blvd., Ste 990, Bloomington, MN, 55437, USA; [2]Michigan Tech Research Institute, 3600 Green Ct., Ste. 100, Ann Arbor, MI, 48105, USA; [3]ECCC, 1125 Colonel by Drive, Ottawa, ON, K1S 5K2, CANADA; [4]Natural Resources Canada, 560 Rochester Street, 6th Floor, Room B3, Ottawa, ON, K1S 5K2, CANADA; [5]CMEO, 560 Rochester Street, 6th Floor, Room C11, Ottawa, ON, K1S 5K2, CANADA; [6]University of Minnesota, PGC, 1954 Buford Ave., St. Paul, MN, 55108, USA; [7]University of Minnesota, RSGAL, 1530 Cleveland Ave. North, St. Paul, MN, 55108, USA; [8]SharedGeo, 1360 University Ave. West, St. Paul, MN, 55104, USA. **Wetland Identification and Change Detection using Multi-sensor, Multi-frequency Remote Sensing.**

Environment and Climate Change Canada, Natural Resources Canada and the US Fish & Wildlife Service are collaborating to develop a multi-sensor, multi-frequency remote sensing approach to mapping and monitoring wetlands. The purpose of this project is to prepare for the upcoming launch of the Radarsat Constellation Mission by determining how simulated compact polarimetry can be used to map and monitor wetlands with multi-temporal sub-meter optical satellite imagery. This multi-sensor and multi-frequency approach will be used to develop wetland indicators derived from remote sensing data that can relate changes in wetland abundance, health, and diversity including avian and amphibian species. There will be four Canadian and US study sites selected based on planned field data collection by ECCC's Canadian Wildlife Service. SAR satellite imagery will be acquired every 24 days (May-Oct) with sub-meter optical satellite imagery as cloud cover and demands permit. The data will be used to create a temporal wetland classification to map and monitor surface water extent, flooded and emergent vegetation, and water levels using the Radarsat-2 data with verification from the sub-meter optical imagery. Later products to be produced include vegetation and water level change maps that will help assess wildlife and wetland health. *Keywords: Remote sensing, Wetlands, Decision making.*

HUCKINS, C.J.[1], HERSCH-GREEN, E.I.[1], MARCARELLI, A.A.[1], GRIMM, A.[2], BROOKS, C.N.[2], ZALLEK, T.[1], LEQUIZAMON, C.M.[1], VAN GOETHEM, R.R.[1], HEILMAN, M.[3], and WILLIS, B.[3], [1]Michigan Technological University, 1400 Townsend Drive, Houghton, Mi, 49930, USA; [2]Michigan Tech Research Institute, 3600 Green Court, Ann Arbor, Mi, 48105, USA; [3]SePRO Corporation, Carmel, IN, 46032, USA. **Eurasian Watermilfoil Response to Herbicide Control and Predictions of its Dispersal.**

Eurasian watermilfoil (*Myriophyllum spicatum*) and its hybrids (invasive watermilfoils, IWM) are prolific invasive macrophytes that have spread throughout Michigan, including coastal waterways of northern Great Lakes. Large inter-annual variations in IWM abundance in the northern Great lakes complicate management efforts. Moreover, *M. spicatum* can hybridize with a native watermilfoil (*M. sibiricum*), resulting in genotypes with potentially reduced sensitivity to commonly used herbicides. We monitored select inland Michigan lakes before and after herbicide application to assess IWM responses to control efforts. Initial results from field surveys and laboratory assays suggest variable growth and sensitivity to standard herbicide applications. We also find that lakes with a history of herbicide application display more diverse IWM genotypes. To prevent new invasions through early detection, we are developing predictive risk and IWM dispersal models based on satellite products, geospatial data on physical and environmental conditions, and records of IWM observations for southern Michigan. This predictive species distribution model indicates a broad environmental niche for IWM, which is a known predictor of a species' invasion success, along with a significant link between dispersal and recreational boating.
Keywords: Invasive species, Vegetation, Biomonitoring.

HUDDLESTON, A.L.[1], HOOD, J.M.[1], MARSCHALL, E.A.[1], MAY, C.J.[2], and LUDSIN, S.A.[1], [1]Aquatic Ecology Lab, Department of Evolution, Ecology, and Organismal Biology, Ohio State University, Columbus, OH, 43212, USA; [2]Department of Biology, Bethel College, Mishawaka, IN, 46545, USA. **The Effects of Warmer Winters on Lake Erie Zooplankton.**

Winters in the North Temperate zone have been warmer and more variable due to climate warming. Unfortunately, we are only beginning to understand how winter conditions influence the structure and function of biological communities in lakes. Warmer winter conditions can alter the physio-chemical environment during the winter, but may also drive changes in phenology and the community dynamics that may persist into the spring. Additionally, warmer conditions favor smaller individuals of zooplankton, phytoplankton, and fish (Daufresne et al. 2009). Winter warming is evident in the Great Lakes where ice cover has declined by 71% over the past four decades (Wang et al. 2012). Warmer winters may be linked to trends of decreased zooplankton densities in Lake Erie from 1994-1999 and from 2011-2013 (May 2015). To better understand how winter conditions influence Lake Erie zooplankton communities, we surveyed Western basin zooplankton communities from March to June in 2011, 2012, and 2013. 2012 was a relatively warm winter, while the western basin was iced-over from January to March of 2011 and 2013. 2012 had a higher mean density of zooplankton but there was no significant difference between the three years. In all three years rotifers had a higher mean than copepods and cladocerans but it was only significant in 2012 and 2013 ($p<0.001$). *Keywords: Climate change, Community dynamics, Zooplankton, Lake Erie.*

HUDSON, M.J., LEHR, R.A., COOPER, M.J., and MCNERNEY, C.J., Northland College, 1411 Ellis Ave, Ashland, WI, 54806, USA. **Tributary and Hydrodynamic Influences on Nearshore Water Quality in Lake Superior's Chequamegon Bay.**

Chequamegon Bay is one of the warmest, shallowest, most isolated, and southerly bays in Lake Superior; and is an ideal location to study the effects of climate change and eutrophication on nearshore water quality. We developed an integrated sampling design to collect baseline data from Chequamegon Bay from 2014 to 2016, to understand how nearshore water quality relates to physical processes and tributary loading. Our approach included 1) installing a series of continuous stream discharge monitoring stations and developing estimates of suspended sediment and phosphorus loading to the Bay, 2) collecting bi-monthly water chemistry profiles, phosphorus, chlorophyll, suspended sediment, and plankton samples from 11 stations in the Bay, and 3) developing a ROMS hydrodynamic model for Chequamegon Bay and the adjacent Lake Superior nearshore, to understand physical influences affecting the interaction between tributaries and nearshore water quality. We found that water quality in Chequamegon Bay is driven by tributary loading patterns; however, spatial and temporal variability in the bay's water quality is highly variable and influenced by watershed inputs and nearshore hydrodynamics. Large storm events over the past two years provide striking examples of how these interacting drivers affect water quality in Chequamegon Bay. *Keywords: Monitoring, Lake Superior, Gages.*

HUMMEL, S.E.[1], ANNIS, M.L.[2], BANDA, J.A.[3], BRIGHAM, M.E.[4], CHOY, S.J.[5], ELLIOTT, S.M.[4], GEFELL, D.J.[6], JORGENSON, Z.G.[7], MOORE, J.N.[8], SCHOENFUSS, H.L.[7], and TUCKER, W.A.[9], [1]U.S. Fish and Wildlife Service, Bloomington, MN, USA; [2]U.S.

Fish and Wildlife Service, East Lansing, MI, USA; [3]U.S. Fish and Wildlife Service, Columbus, OH, USA; [4]U.S. Geological Survey, Mounds View, MN, USA; [5]U.S. Fish and Wildlife Service, Madison, WI, USA; [6]U.S. Fish and Wildlife Service, Cortland, NY, USA; [7]St. Cloud State University, St. Cloud, MN, USA; [8]U.S. Fish and Wildlife Service, Chubbuck, ID, USA; [9]U.S. Fish and Wildlife Service, Bloomington, IN, USA. **Characterizing Contaminants of Emerging Concern in the Great Lakes Basin.**

The spatial and temporal occurrence of contaminants of emerging concern (CECs) is not well characterized in the Great Lakes Basin. The U.S. Fish and Wildlife Service, in collaboration with the U.S. Geological Survey, is leading a study to evaluate the occurrence of CECs in the Great Lakes Basin. The objective is to characterize the spatial and temporal distribution of CECs in water and sediment. Samples were collected from 25 U.S. Great Lakes tributaries and analyzed for a broad suite of CECs. Chemicals classified as alkyphenols, flavors/fragrances, steroid hormones, PAHs, and sterols had higher average detection frequencies in sediment compared to water, while the opposite was true for pesticides, and plasticizers/flame retardants. Tributaries located in highly urbanized areas or with multiple point sources such as wastewater treatment plants or combined sewer overflows had the most CEC detections, as well as the highest concentrations. No consistent temporal patterns in CEC occurrence were observed at locations sampled multiple times each day. Results from this study will help us better understand effects of CECs on fish and wildlife resources in the Great Lakes basin and develop management recommendations to mitigate deleterious impacts. *Keywords: Great Lakes Restoration Initiative (GLRI), Environmental contaminants, Spatial distribution.*

HUNT, D.S. and KASHIAN, D.R., Wayne State University, 5047 Gullen Mall, Detroit, MI, 48202, USA. **Impacts of Dreissenid Shells on Benthic Habitat and Macroinvertebrates in Great Lakes Tributaries.**

The physical effects of dreissenid invasions are well documented in the Great Lakes, but few studies have assessed impacts in their tributaries. Dreissenid mussels alter benthic habitats by aggregating on substrates, dying off, and leaving mass quantities of shells behind. Shell deposits can homogenize habitat, covering gravel and cobble spawning substrates used by Great Lakes fish. We quantified dreissenid shell densities in Great Lakes tributaries, and evaluated their impact on macroinvertebrates found in nurseries of migratory fish in the Rouge and Huron Rivers. In both rivers, shell coverage reached the highest densities downstream of dams. Invertebrate communities were characterized in each river where surface area cover represented 0, 10, 75, 100% shells. The percent of the surface area covered in shells did not affect macroinvertebrate total abundance ($p>0.05$) in either river, however, community composition varied among coverage classes. Differences in

invertebrate diversity was reported at high shell densities in the Rouge ($p<0.05$) and Huron Rivers ($p<0.05$), and lower relative abundances of EPT taxa ($p<0.05$) were noted in the Huron River. Dreissenid shell densities can alter invertebrate communities potentially degrading fish nurseries in Great Lakes tributaries, indicating an overall decline in stream ecosystem health. *Keywords: Benthos, Macroinvertebrates, Dreissena.*

HUNT, L.E.F., PAVLOVIC, N.B., and GRUNDEL, R., U. S. Geological Survey, 1574 Kemil, Chesterton, IN, 46304, USA. **Great Lakes Coastal Connectivity and Improvement Analysis.**

Ecologists have sought to analyze connectivity for years in an effort to better understand the ecological effects of fragmentation on the landscape. Originally, small scale connectivity analyses were used to understand individual movement and local population distributions. As scientists began expanding the scope, scale, and size of studies, model complexity increased and was restricted by computational capacity, forcing development of new technologies to overcome these limitations. Using the NLCD, we created a layer indicating resistance to potential movement/dispersal, in order to evaluate connectivity along the Great Lakes coast. We used Circuitscape, which applies circuit theory, to map connectivity across our study area, and identify specific parcels of land vital to improving connectivity. This framework was used as a case study to inform Indiana Dunes National Lakeshore managers where best to invest their limited resources in order to maintain or connectivity. The second part of this analysis expands the study's scope to the entire Great Lakes shoreline, using PAD-US to compare the connectivity of State and Federal protected areas, determining where connectivity is most tenuous, overlapping this with predictions of future connectivity, to identify critical regions for maintaining long term connectivity. *Keywords: Remote Sensing, Coastal ecosystems, Connectivity, Assessments, GIS.*

HUNTER, R.D.[1], SCRIBNER, K.T.[1], ROSEMAN, E.F.[2], DEBRUNYE, R.[3], and FYKE, Z.P.[2], [1]Department of Fisheries and Wildlife, Michigan State University, 480 Wilson Road, East Lansing, MI, 48824, USA; [2]U.S. Geological Survey, Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105, USA; [3]University of Toledo, Department of Environmental Sciences, 2801 West Bancroft Street, Toledo, OH, 43606, USA. **Pedigree Analysis Allows Assessment of Lake Sturgeon Reproduction Associated With Artificial Reefs.**

Lake Sturgeon (*Acipencer fulvescens*) is an economically and culturally important species endemic to the Laurentian Great Lakes. Once historically abundant, many current lake sturgeon populations have been extirpated or are estimated at less than one percent of their historic abundance. As a result of large scale habitat modification, the St. Clair Detroit River

System (SCDRS) was declared an Area of Concern. Since 2004, large scale efforts have been under way to increase spawning habitat for lithophilic spawners such as lake sturgeon through the construction of artificial spawning reefs. To assess the effectiveness of artificial reefs in meeting lake sturgeon restoration goals, eggs and larvae were collected on and above two reefs in 2015. Larvae were genotyped using microsatellite loci and likelihood-based pedigree analyses were used to identify juvenile full- and half-sibling groups and estimate the effective number of breeding adults. Data allow for estimation of the number of adult spawners contributing offspring at one or more reefs, in one or more spawning events, individual spawning success and larval dispersal. Genetic data are critical to assess and inform future aquatic habitat restoration efforts and monitor reproductive success of lake sturgeon throughout the Great Lakes. *Keywords: Genetics, Lake sturgeon, Remediation, Area of concern, Assessments, Artificial reef.*

HUNTER, R.D.[1], ROSEMAN, E.F.[2], DEBRUYNE, R.[3], SCHMIDT, B.A.[4], BOWSER, D.A.[2], IRELAND, S.A.[2], KENNEDY, G.[2], CHIOTTI, J.A.[4], JOHNSON, J.L.[4], KAULFERSCH-FISCHER, L.A.[5], and HONDZINSKI, A.[2], [1]Department of Fisheries and Wildlife, Michigan State University, 480 Wilson Rd., East Lansing, MI, 48825, USA; [2]U.S. Geological Survey, Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105, USA; [3]University of Toledo, Department of Environmental Sciences, 2801 West Bancroft St., Toledo, OH, 43606, USA; [4]U.S. Fish and Wildlife Service, Alpena FWCO-Waterford Substation, 480 West Fletcher St., Alpena, MI, 49707, USA; [5]U.S. Fish and Wildlife Service, Environmental Services, 2651 Coolidge Rd., East Lansing, MI, 48823, USA. **Evidence of Immediate and Continued Use of Artificially Constructed Reefs by Spawning Lake Sturgeon.**

The St. Clair-Detroit River System (SCDRS) is a 115 km waterway connecting Lake Huron to Lake Erie. Beginning in the early 1900's, large scale modifications to the river bottom resulted in the removal of considerable lithophilic spawning habitat through the construction of shipping channels and disposal of dredge spoils. In1987, the St. Clair and Detroit rivers were designated as Areas of Concern. Additionally, lake sturgeon (*Acipencer fulvescens*), a culturally and economically important lithophilic spawner endemic to the Laurentian Great Lakes, have been listed as a threatened species in the state of Michigan. In order to increase the availability of spawning habitat for lake sturgeon, seven artificial spawning reefs were constructed throughout the SCDRS. Egg mats, benthic D-frame nets, and stratified conical nets have been used to assess the response of fish to the reefs. Assessment data provided evidence of immediate and continued use of the reefs by spawning lake sturgeon and survival of eggs to the larval stage. Remediation efforts aimed at addressing factors limiting reproductive success of lake sturgeon and other threatened and endangered species are critical to recovery, and lessons learned in the SCDRS provide a framework for future remediation efforts throughout the Great Lakes. *Keywords: Remediation, Lake sturgeon, Detroit River, Area of concern, St. Clair River, Artificial reef.*

HYDE, T., US EPA, Chicago, USA. **Opening Remarks for Restoring Great Lakes Areas of Concern.**

Areas of Concern (AOCs) have been a feature of the Great Lakes Water Quality Agreement between Canada and the United States since 1987. The Agreement was revised in 2012 and AOCs are now profiled in Annex 1. In her opening remarks, Tinka Hyde, Director of the Great Lakes National Program Office, U.S. Environmental Protection Agency and one of the principal implementers of the revised Agreement, will outline the purpose, objectives and implementation of the 2012 Great Lakes Water Quality Agreement with emphasis on the AOC program. She will highlight the progress, priorities, management structure, evaluation and outreach to all parties to remove impairments and the delisting of the 29 remaining U.S. and binational AOCs. She will address the progress the U.S. agencies have made in removing the impairments and delisting AOCs based upon the influx of resources from the Great Lakes Restoration Initiative and how EPA is meeting the targets set for it in the Great Lakes Action Plans I and II. She will conclude with a projection of what will be accomplished in the near future based upon work completed to date and anticipation of additional resources for the AOC program. *Keywords: Great Lakes Restoration Initiative (GLRI), Remediation.*

I

ILAMPOORANAN, I. and BASU, N.B., Department of Civil and Environmental Engineering, University of Waterloo, 200 university avenue west, Waterloo, ON, N2L 3G1, CANADA. **Modeling nitrogen legacies and time lags in agricultural landscapes using SWAT.**

Massive land-use changes and the industrial production of fertilizers have increased food production, but at the cost of significantly altering the global nitrogen (N) cycle. Best management practices (BMPs) implemented to improve water quality have generally met with limited success. We hypothesize that such lack of success is due to increased build up of legacy N stores in the subsurface that act as an additional source even when N inputs have been reduced. Here, we used Soil Water Assessment Tool to understand and quantify the magnitude and spatial patterns of legacy nitrogen stores and their timescales of depletion in a 502 sq.km agricultural watershed in Iowa. Using a more recent modification, SWAT

simultaneously captured the observed N accumulation in the root zone, nitrate and organic N concentrations in the stream. A simultaneous, multi-objective calibration and validation was done from 1949 to 2015. This is the first application of the SWAT model that captures multiple N species, in both the stream and soil. The model was then run with various watershed conservation scenarios and time lags in response of stream nitrate concentrations was quantified. This framework, for the first time, provides an explicit quantification of the watershed scale time lags to achieve water quality benefits due to agricultural BMPs.
Keywords: Time lags, Nitrogen, Modeling, SWAT.

IONESCU, R.A., BIRCEANU, O., and WILKIE, M.P., Wilfrid Laurier University, 75 University Ave., Waterloo, ON, N2L 3C5, CANADA. **A Pathophysiological Study on the Effects of TFM on Lake Sturgeon (*Acipenser fulvescens*).**

Petromyzon marinus are parasitic sea lampreys that have been threatening fish populations since the 19th century in the Great Lakes. The discovery of 3-trigluoromethyl-4-nitrophenol (TFM), has enabled the targeting of multiple generations of lamprey by destroying the larvae in tributaries and rivers of the Great Lakes, while minimizing the effect on non-target fishes. The detoxification process requires the glucuronidation of the lampricide(s), catalyzed by UDP-glucuronyltransferase (UDPGT), an enzyme abundant in most non-target fishes but highly reduced in sea lamprey. This characteristic makes sea lampreys much more sensitive to TFM compared to other fishes. Despite rigorous efforts, occasional non-target fish kills do occur. One important species affected by these fish kills, is the protected *Acipenser fulvescens* (lake sturgeon), which has been suggest to have lampricide sensitivity similar to sea lamprey. Using pathophysiological and toxicological methods, this study endeavours to shed light on the underlying mechanisms by which lake sturgeon are rendered more sensitive to lampricides compared to other non-target fishes. This work will help improve lamprey control efforts while maximizing the protection of economically and culturally important fishes such as the lake sturgeon. *Keywords: Fish management, TFM, Fisheries, Lampricide, Fish toxins, UDPGT.*

IRAMBONA, C., MUSIC, B., and FRIGON, A., Ouranos, Consortium on Regional Climatology and Adaptation to Climate Change, 550 Rue Sherbrooke O., Montreal, QC, H3A 1B9, CANADA. **Great Lakes Water Supply as simulated by the NA-CORDEX and Canadian Regional Climate Models.**

Climate change is expected to affect the Laurentian Great Lakes hydrological cycle. To study the effects of increasing levels of greenhouse gases on Great Lakes water resources, we perform a climate change assessment study using several recently generated Regional Climate Model (RCM) simulations. These include simulations from two Canadian RCM

(CRCM5 and CanRCM4) as well as simulations generated by at least two other models (RCA4 and HIRHAM5) that participated in the North American CORDEX Program (NA-CORDEX). Our analysis will focus on the Net Basin Supply (NBS), which provides valuable information on the Great Lakes water resources availability. Analyses will also include surface energy fluxes over the lake and land parts of the Great Lakes basin, such as net radiation, latent and sensible heat. Moisture recycling, which indicates the importance of surface-atmosphere interactions in the regional hydrological cycle, will also be investigated through the so-called precipitation-recycling ratio. *Keywords: Hydrologic cycle, Climate change, Great Lakes basin.*

IRAMBONA, C., MUSIC, B., HUARD, D., and FRIGON, A., Ouranos, Consortium on Regional Climatology and Adaptation to Climate Change, 550 Rue Sherbrooke O., Montreal, QC, H3A 1B9, CANADA. **Lake Ontario Water Temperature in a Changing Climate.**

The efficiency of nuclear power plants operated by Ontario Power Generation (OPG) is affected by the temperature of cooling water drawn from the Lake Ontario. Since climate change may have considerable effects on lake water temperature, quantitative projections of possible changes in future cooling water temperature are of great interest for OPG. In this study we employed two simple approaches to evaluate water temperature changes at the 2050 horizon for the summer period (July-August-September) using air temperature projections from an ensemble of Regional Climate Model (RCM) simulations based on two future GHG scenarios: RCP4.5 and RCP8.5. The first approach consists of evaluating future water temperatures knowing the relationship between historical air and water temperatures and assuming that this relationship will hold under future climate conditions. The second method is based on the air2water model, a hybrid physically based/statistical model, which takes into account the heat budget of the lake's surface volume. The model was calibrated with long-term water and air temperature observations that include water temperatures from Darlington Nuclear Power Station's intake. Both methods suggest an increase in Lake Ontario summer water temperatures in the order of 1°C. *Keywords: Model studies, Climate change, Lake Ontario.*

IRVIN, K.M.[1], HAPPEL, A.[2], and RINCHARD, J.[1], [1]The College at Brockport - State University of New York, Brockport, NY, 14420, USA; [2]University of Illinois - Illinois Natural History Survey, Zion, IL, 60099, USA. **Use of Fatty Acid Signatures to Explore the River Continuum Concept.**

The objective of this study was to evaluate if fatty acid signatures (FAS) of aquatic organisms could be used to assess the river continuum concept (RCC), which predicts biological community responses to physical changes from headwaters to the mouth of any river. Nine sites were chosen throughout the Genesee River, located in Western New York. Largemouth bass, smallmouth bass, northern hogsucker, red horse sucker (e.g., golden, silver, greater, black), and rock bass were collected using backpack or boat electrofishing at each site during the spring and summer of 2016. Gas chromatography/mass spectrometry was used to assess whole body fatty acid signatures of each species. Water quality (e.g., dissolved oxygen, conductivity, pH, temperature, total nitrogen (TN) and total phosphorus (TP)) was evaluated during both seasons to confirm the RCC. Temperature, TN and TP were higher in the mouth during the spring, which followed the RCC prediction. Dissolved oxygen was higher in the mouth of the river during both seasons, which did not follow the prediction. Conductivity and acidity showed trends to be higher in the mouth during both seasons. We will compare changes in FAS of each species throughout the river and discuss any diet shift linked to the RCC (terrestrial/microbial sources in the headwaters to instream sources in the mouth). *Keywords: River Continuum Concept, Fatty Acids, Genesee River.*

ISAAC, J.L., Office of the Environmental Commissioner of Ontario, 1075 Bay Street, Suite 605, Toronto, ON, M5S 2B1, CANADA. **Stormwater Fees: Reforming Ontario Stormwater Management Funding Model.**

In *Urban Stormwater Fees: How to Pay for What We Need*, the Environmental Commissioner of Ontario (ECO) found that Ontario's current stormwater funding model, primarily property taxes, development charges and government grants, is not working. The ECO conducted a survey of Ontario municipalities and found that: 65% of the municipalities that responded are not recovering the full costs associated with managing stormwater; 43% of municipalities that responded do not have an asset management plan for stormwater management facilities/systems; and that 35% of municipalities that responded are considering implementing an alternative funding model: stormwater fees. Stormwater fees can provide a more dedicated, stable, fair and equitable funding source and better promote green infrastructure than the current funding model. Stormwater fees are already in use by 8 Ontario municipalities including Mississauga and Kitchener. The ECO recommended that all municipalities be required to prepare asset management plans for their grey and green stormwater infrastructure and that provincial government provide more support to municipalities in implementing stormwater fees. Without enough funds to manage stormwater, there could be more overland and basement flooding, sewage bypasses, beach closure days, and sediment in lakes and rivers. *Keywords: Stormwater management, Environmental policy.*

ISELY, E.S.[1], ISELY, P.[2], NORDMAN, E.[2], and DENNING, R.[2], [1]West Michigan Environmental Action Council (WMEAC), 1007 Lake Drive SE, Grand Rapids, MI, 49506, USA; [2]Grand Valley State University, 1 Campus Drive, Allendale, MI, 49401, USA. **Rainwater Rewards: Stormwater Green Infrastructure Ecosystem Services Calculator.**

WMEAC and GVSU have developed an online stormwater tool that calculates costs and benefits of ecosystem services associated with implementation of green infrastructure practices such as rain gardens, tree pits/planters, porous pavement, green roofs, rain barrels, bioretention/infiltration ponds, and conservation of natural areas. The primary ecosystem services associated with urban green infrastructure implementation include avoided volume of water, flood risk reduction, water pollution reduction (total suspended solids and phosphorus), property value amenity, energy savings, air pollution reduction, and carbon dioxide storage. The calculator, called Rainwater Rewards, can be found online: rainwaterrewards.com The basic user, such as a residential or commercial property owner, can enter relatively minimal information describing the site, and a description of the green infrastructure practice(s) proposed or already in place, to calculate an annual baseline stormwater runoff, as well as the costs and benefits of the ecosystem services at the census block level. An advanced user, such as a municipal environmental services manager, can enter additional information more specific to the site and proposed green infrastructure practice(s). The calculator was designed for small- to medium-sized cities in the Great Lakes Basin. *Keywords: Green infrastructure, Decision making, Stormwater, Economic evaluation, Urban watersheds, Ecosystem services.*

IVAN, L.N.[1], BRENDEN, T.O.[1], STANDISH, I.F.[2], and FAISAL, M.[1], [1]Michigan State University, East Lansing, MI, USA; [2]US Fish and Wildlife Service, Onalaska, WI, USA. **Can stocking vaccinated fish protect a Great Lakes fish population from infectious diseases?**

Immunization of a wild fish population poses many logistical challenges, but vaccination and stocking of hatchery fish offer a potential means of protecting populations from infectious diseases. We constructed an individual-based model to evaluate the effectiveness of vaccinating hatchery-raised fish to protect wild Lake Michigan Chinook salmon Oncorhynchus tshawytscha against a VHS-like disease. Simulations tracked growth, movement, mortality, reproduction and disease transmission among fish for 25 years. Factors of interest included fish clustering, infection and mortality probability, number of vaccinated hatchery fishes, and reshedding by recovered fishes. Stocking 2.4 million fish decreased the average infection rate over the last 10 simulated years by 60-80%. Doubling the stocking level resulted in similar protection levels but greater abundances. Vaccination had the greatest impact under low infection, high mortality rate, and high degree of clustering assumptions. Disease eradication only occurred when recovered individuals could not resume viral shedding. Our modeling efforts show that a vaccination program based on the immunization of hatchery fish can help protect wild fish populations, although 100% protection may be difficult to achieve when recovered fish can continue infecting susceptible individuals. *Keywords: Chinook salmon, Fish populations, VHS, Fish diseases, Model studies.*

J

JACOBS, K. and TENBULT, A., Ontario Soil and Crop Improvement Association, 1 Stone Road West, Guelph, ON, N1G 4Y2, CANADA. **Putting A Price On Phosphorus: How On-Farm Actions Are Improving The Health Of The Great Lakes.**

The Great Lakes Agricultural Stewardship Initiative (GLASI) is testing new approaches that show targeted agricultural stewardship, backed with education and financial incentives, can have a positive impact on the health of the Great Lakes. Through the use of a ground-breaking farmland health assessment, producers are taking a critical look at their impact on water quality by assessing soil health on their farm. With the support of Certified Crop Advisors to evaluate areas on-farm that would benefit from the implementation of Best Management Practices (BMPs), farmers can make key changes to their farm practices with funding available through merit-based GLASI programs. Water quality improvements that result from GLASI-funded on-farm actions are being quantified through partnerships with four Conservation Authorities. Extensive water quality monitoring networks have been established in key subwatersheds. Data will be combined with a modeling exercise and a Cost Benefit Analysis to determine what the cost to society is, in $/kg of removed phosphorus, to improve water quality using agricultural stewardship. Funding for GLASI is provided by Agriculture and Agri-Food Canada and the Ontario Ministry of Agriculture, Food and Rural Affairs through Growing Forward 2. *Keywords: Great Lakes basin, Agriculture, Conservation, Soil Health, Water quality, Innovative Program Design.*

JEON, Y., LIU, L., CHOI, O., MOHSEN, B., and SEO, Y., University of Toledo, 2801 W. Bancroft Street, 3031 Nitschke hall, Toledo, OH, 43606, USA. **Effect of Potassium Permanganate Pretreatment on Water Quality and Cyanobacterial Cell Integrity.**

Harmful algal blooms (HABs) have caused significant effects on drinking water production since they were continuously detected in fresh water sources. Researchers reported that various pre-oxidation techniques such as chlorination, ozonation, and potassium permanganate treatment can enhance the removal of cyanobacteria cells in the conventional water treatment process. However, these techniques can also result in the release of problematic intracellular toxins and various algal organic matter (AOM) that causes disinfectant byproduct (DBP) formation, and taste and odor problems. Previously, most studies focused on evaluating Microcystis aeruginosa as a model cyanobacterium, even though mixtures of algae with high concentration of natural organic matter are commonly found in fresh water systems. In this study, we evaluated the influence of water quality parameters and algae species on algal cell integrity, DBP formation (both regulated and unregulated DBPs) and microcystin-LR releases during potassium permanganate pre-oxidation step using both homogenous M. aeruginosa and different algae impacted samples from Lake Erie and Lake Mary in Ohio. Chemical composition changes and reaction site of treated algae, algal extracellular organic matters, and intracellular organic matter were also analyzed using various analytical techniques. *Keywords: Environmental health, Toxins, Harmful algal blooms, Microcystin, Water quality, Cyanobacteria.*

JEON, Y., LEE, S., and SEO, Y., University of Toledo, 2801 W. Bancroft Street, 3031 Nitschke hall, Toledo, OH, 43606, USA. **Microbial community dynamics on granular activated carbon (GAC) of biofiltration systems in response.**

As the occurrence of harmful cyanobacterial bloom increases around world, many drinking water treatment plants (DWTPs) with conventional water treatment processes concerns about cyanotoxin removal as exposures to cyanotoxins may cause serious risks to animal and human health, and lead to economic losses. Biological filtration systems (BFS) in DWTPs recently received much attention due to its potential to degrade or transform various contaminants such as disinfection by-product (DBP) precursors, taste and odor causing compounds, and emerging contaminants with increased concerns with low maintenance and energy input. In this study, lab-scale column reactors filled with granular activated carbon (GAC) were operated continuously to understand how microbial communities in BFS response to cyanotoxins. Microbial community changes were monitored using Illumina MiSeq high-throughput sequencing technique, targeting on the bacterial and archaeal 16S rRNA genes. Resulted paired-end sequences were merged and analyzed using USEARCH 8.1 and QIIME software, respectively, and further statistical analyses were conducted using R software. The results of this study indicates that specific microbial communities were predominated and activated in response to the presence of cyanotoxins in feeding water. *Keywords: Harmful algal blooms, Microbial community, Water quality, Cyanotoxin, Biofilm.*

JETOO, S. and JOAS, M., Abo Akademi, Vänrikinkatu 3 A, Turku, 20500, FINLAND. **Comparison of Operationalizing the Ecosystem Approach in the Great Lakes and the Baltic Sea.**

The Laurentian Great Lakes and the Baltic Sea are two large transboundary water systems in North America and Europe. These water bodies share a similar history, each signing a transboundary governance agreement in the early 1970s due to concerns of water pollution. In 1972, the Great Lakes Water Quality Agreement was signed between Canada and the United States of America, leading to the establishment of the International Joint Commission (IJC). At the same time in Europe, negotiations were ongoing for a transboundary agreement culminating in a transboundary water agreement in 1974, the Helsinki Convention, which established the Helsinki Commission (HELCOM). Whilst these commissions can be seen as successes because they were effective in bringing the key national players to the table, the continued degradation of these transboundary water ecosystems would suggest that they are not yet successful in applying the ecosystem approach to governance. This paper investigates the effectiveness of these transboundary water commissions in operationalizing the ecosystem based approach to governance by assessing their adaptive capacity, the governance capacity for dealing with change. It uses a framework for adaptive capacity from the literature and assesses the performance of these transboundary commissions against these principles. *Keywords: Transboundary water commissions, Environmental policy, Great Lakes basin, Ecosystems, Adaptive capacity, Baltic Sea.*

JI, X.[1], ROOD, R.B.[1], DAHER, H.[2], GRONEWOLD, A.D.[2], and BOLINGER, R.[2], [1]climate and space science and engineering, University of Michigan, 2455 Hayward St, Ann Arbor, MI, 48109, USA; [2]NOAA Great Lakes Environmental Research Laboratory, 4840 S State Rd, Ann Arbor, MI, 48108, USA. **Simulating and forecasting seasonal ice cover.**

Over the past several decades, dramatic changes in the spatial extent of seasonal and long-term ice cover have been documented for both marine and continential water bodies. Successfully projecting future changes in global ice cover requires an understanding of the drivers behing these historical changes. Here, we explore relationships between continental climate patterns and regional ice cover across the vast surface waters of the Great Lakes. Our findings indicate that abrupt historical changes in Great Lakes seasonal ice cover are coincident with historical changes in teleconnections, including both the El Nino Southern Oscillation (ENSO) and Pacific Decadal Oscillation (PDO). We find, in particular, that these teleconnections explain much of the ice cover decline in the late 1990s (coincident with the strong 1997-1998 winter El Nino) and the following persistent period of below-average period of ice that followed. We encode these relationships in a probabilistic model that provides seasonal projections of ice cover areal extent across the Great Lakes, as well as specific spatiotemporal patterns in ice cover at resolutions that align with critical regional human health and safety-related management decisions. *Keywords: Decision making, Teleconnection, Ice, Modeling.*

JIANG, X.[1], LEE, S.[2], KWON, J.[3], GORHAM, T.J.[4], CHO, H.[3], and LEE, J.[4], [1]Department of Food Science and Technology, The Ohio State University, 2015 Fyffe Ct, Columbus, OH, 43210, USA; [2]Environmental Science Graduate Program, The Ohio State University, 1841 Neil Ave, Columbus, OH, 43210, USA; [3]Department of Mechanical and Aerospace Engineering, The Ohio State University, 201 W 19th Ave, Columbus, OH, 43210, USA; [4]College of Public Health, Division of Environmental Health Sciences, 1841 Neil Ave, Columbus, OH, 43210, USA. **Characterization of cyanophages from Lake Erie that suppress Microcystis growth.**

Cyanophages are viruses infecting cyanobacteria to deter or promote their growth. The main goal of this study was to isolate and characterize cyanophages from Lake Erie that have lytic activity against *Microcystis aeruginosa*. Water samples were collected from Lake Erie (2013-2015) and concentrated to screen the presence of lytic cyanophages. The best candidates were incubated with toxin-producing *M. aeruginosa* (host) to monitor the impact of cyanophages on their growth. Atomic force microscope (AFM) and transmission electron microscope (TEM) were used to elucidate the interaction mechanisms between the cyanophage and the host. The whole genome sequencing and PCR were performed to identify the cyanophage. Cyanophages inhibited the growth of hosts and decreased their photosynthesis when checked with the essential pigment productions. TEM images revealed that the cyanophages are a short-tailed virus with special proteins on the capsid, indicating the presence of a new *Podoviridae*, which was further confirmed by PCR targeting *psbA* gene. AFM images showed the attachment of the cyanophages on their host and structural damage of the hosts. This is the first study reporting the *Podoviridae* that suppress *M.aeruginosa* growth and applying AFM to innovatively describe the virus-host interaction. *Keywords: Lysis, Atomic force microscope, Microcystis, Cyanophage, Harmful algal blooms.*

JINGE, Z. and WEI, L., Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences, 73 East Beijing Road, Nanjing, JS, 210008, CHINA. **Response of aqutic vegetation to Nymphoides peltata harvest in a large shallow lake.**

A large area (196 square kilometers) of floating-leaved Nymphoides peltata was harvested in Lake Taihu in 2013. The impact of harvesting on the coverage and biomass of N. peltata and of the submerged plant community was evaluated. Harvesting caused an immediate reduction in the coverage of N. peltata, and its coverage for the following year varied from 29.2% to 95.1%. Wave conditions and interspecific competition were the main factors that influenced the response of the submerged plant community to N. peltata harvesting. Harvesting may favor the dominance of Hydrilla verticillata, which expands quickly at a growth rate of 53.3 g per square meters per day. This variation could increase the

coverage and spread of the submerged plants, improve the plant community and subsequently improve the water quality. *Keywords: Ecosystems, Management, Vegetation.*

JOHENGEN, T.H.[1], PAIGE, K.[2], RUBERG, S.A.[3], TWISS, M.R.[4], and PEARSON, R.[2], [1]CILER, University of Michigan, 440 Church Street, Ann Arbor, MI, 48109, USA; [2]GLOS, 4840 South State Rd, Ann Arbor, MI, 48108, USA; [3]NOAA Great Lakes Environmental Research Lab, 4840 South State Street, Ann Arbor, MI, 48108, USA; [4]Clarkson University, Potsdam, NY, 13699, USA. **State of the Science for Great Lakes Observations: Conclusions from the 2016 CILER Symposium.**

Two dozen researchers and government representatives from the United States and Canada convened in a summit hosted by the University of Michigan, Cooperative Institute for Limnology and Ecosystem Research (CILER). Over the course of two days, participants discussed how the Great Lakes Observing System (GLOS) can be improved to meet environmental management challenges. This presentation will highlight the key results from the summit that touch on the identifying the data gaps in GLOS and the challenges in sustaining it into the future. Data gaps include winter observation, capturing lake and connecting channel data in non-Cooperative Science and Monitoring Initiative years, as well as the need for more sophisticated sampling platforms. The presentation will conclude with a vision of how to best address these challenges in the near future. *Keywords: Observing systems, Great Lakes basin, Ecosystem forecasting.*

JOHNSON, J.L.[1], CHIOTTI, J.A.[1], BRIGGS, A.S.[1], BOASE, J.C.[1], ROSEMAN, E.F.[2], and HESSENAUER, J.M.[3], [1]U.S. Fish and Wildlife Service, Waterford, MI, USA; [2]U.S. Geological Survey, Ann Arbor, MI, USA; [3]Michigan Department of Natural Resources, Harrison Township, MI, USA. **Northern Madtom (Noturus stigmosus) use of artificial reefs in the St. Clair - Detroit River System.**

The Detroit and St. Clair Rivers historically supported an abundant fishery; however, these rivers have been greatly altered. The creation of navigation channels and other anthropogenic disturbances have resulted in the decline of native fish populations and loss of habitat. In order to restore these beneficial use impairments, artificial reefs have been constructed. One species to potentially benefit from the construction of artificial reefs is a small, endangered catfish, Northern Madtom. Not much is known about this species, so in the summer of 2016, we sampled artificial reefs and nearby control sites in the Detroit and St. Clair rivers to compare the relative abundance of these fish. Minnow traps were deployed overnight at three reef and control sites in each river. A total of 429 minnow traps were deployed using four different bait types to determine bait preference. A total of 51 Northern Madtom were caught, 47 of which were in the St. Clair River. Relative abundance did not differ between reef and control sites. However, Northern Madtom statistically preferred night crawlers over any other bait type. This work provides insight regarding sampling strategies to target Northern Madtom in large river systems and future sampling will occur over a longer temporal scale to identify seasonal patterns in habitat use. *Keywords: Threatened and Endangered Species, Fisheries, Connecting Channels, Restoration.*

JOHNSON, R.J.[1], PÉREZ-FUENTETAJA, A.[1], PETTIBONE, G.W.[1], SNYDER, R.J.[1], and CLAPSADL, M.[2], [1]SUNY Buffalo State, 1300 Elmwood Ave, Buffalo, NY, 14222, USA; [2]Great Lakes Center, 1300 Elmwood Ave, Buffalo, NY, 14222, USA. **Evaluating immune responses of emerald shiners (*Notropis atherinoides*) in the Niagara River.**

Emerald shiners are a critical prey species for many predatory fish and birds in the Niagara watershed. The objective of this research was to evaluate the health of emerald shiners captured from the upper Niagara River, where there is intermittent fecal pollution from combined sewer overflows (CSOs). Water samples were taken biweekly from seven sites in the upper Niagara River and one site in Lake Erie to determine the *Escherichia coli* most probable number (MPN)/100 mL (May-October 2016). Concurrently, emerald shiners were captured from riverine sites and necropsied using a modified Health Assessment Index (HAI). This method incorporated nine physiological parameters to approximate health status. A sub-sample of fish were tested for bacterial contamination in the liver, which can occur in waters with high bacterial load. *E. coli* MPN were statistically different among sites. Fish had poorest HAI scores in May and August, and 35.3% of the sampled emerald shiners had internal bacterial contamination. Other observed signs of stress were elevated leukocrits, hemorrhaging and high parasite loads. Evaluating the immune stress due to sewage input of this important fish species provides insight into whether the Niagara River ecosystem is functionally adequate to preserve the health of aquatic organisms. *Keywords: Fish diseases, Niagara River, Biomonitoring, E. coli, Water quality.*

JONAS, J.L.[1], BRONTE, C.R.[2], CZESNY, S.J.[3], HAPPEL, A.[3], KORNIS, M.S.[2], RINCHARD, J.[4], and SCHAICK, S.[1], [1]Michigan Department of Natural Resources, 96 Grant Street, Charlevoix, MI, 49727, USA; [2]US Fish and Wildlife Service, 2661 Scott Tower Drive, New Franken, WI, 54229, USA; [3]Illinois Natural History Survey, 400 17th Street, Zion, IL, 60099, USA; [4]SUNY at Brockport, 117 Lennon Hall, Brockport, NY, 14420, USA. **The ever changing prey of lake trout in Lake Michigan.**

A rapidly changing forage base in Lake Michigan, precipitated by invasive species, has complicated our understanding of foraging patterns for native lake trout. We evaluated spring diet observations from 1996-2016 gill net surveys in Michigan waters (MIDNR) and summer diet assessments from 2015 angler catches lake-wide (USFWS/INHS) to explore

spatial and temporal patterns. Spring lake trout diets in Michigan waters were comprised primarily of pelagic species like alewife, rainbow smelt, and bloater prior to 2002, after which round goby began to play an increasingly important role. Increased reliance on round goby was first observed in southern Lake Michigan, followed by the north when in 2012 gobies began to compose a large portion of the diet. By contrast, diets in angler harvested fish from May - August 2015 indicated a higher proportion of alewife in lake trout diets than in those captured in spring gill nets, both in Michigan waters and lakewide. Fatty acid signatures were assessed on from subsets of fish collected in both efforts which suggest spatial segregation in lake trout diets. We suggest the influence of season (goby migrations), location and collection method (benthic gillnets vs. pelagic angling) are important when interpreting diet information and assessing the relative importance of species like round goby.
Keywords: Round goby, Lake trout, Diets.

JONASEN, K.L.[1], DUB, J.D.[2], THOMAS, S.M.[3], and CZESNY, S.J.[1], [1]Lake Michigan Biological Station, Illinois Natural History Survey, University of Illinois U-C, 1816 S. Oak Street, Champaign, IL, 61820, USA; [2]ECS Federal, LLC, National Marine Fisheries Service, 1315 E. West Hwy, Silver Spring, MD, 20910, USA; [3]Waterford Fisheries Station, Michigan Department of Natural Resources, 7806 Gale Rd., Waterford, MI, 48327, USA. **Competitor, Prey Item, or Both: Exploring Costs and Benefits of Round Goby to Juvenile Yellow Perch.**

Species invasions have led to dramatic environmental changes in the Great Lakes over recent decades, and contributed to the widespread recruitment failure of a popular native sportfish in Lake Michigan, the yellow perch (*Perca flavescens*). The expansion of the invasive round goby (*Neogobius melanostomus*) may be further impacting juvenile yellow perch survival and recruitment through competition for preferred invertebrate prey and rocky habitats along the Illinois coast. However, round gobies could also be providing a benefit. Round gobies spawn multiple times per year and produce numerous offspring, which may serve as energy-rich prey for small yellow perch. To tease apart these potential costs and benefits, we assessed diet overlap and yellow perch piscivory as a proxy for competition across habitats and yellow perch size classes. Results of this study reveal spatial and size-dependent differences in diet overlap with round gobies and high relative consumption of round gobies by yellow perch at sizes smaller than previously documented in Lake Michigan. Continued research will help determine the implications of this uncharacteristically early shift to piscivory, and emphasize the importance of diet overlap in the assessment of invasive species impacts in the Great Lakes. *Keywords: Invasive species, Fish diets, Coastal ecosystems, Yellow perch, Lake Michigan, Round goby.*

JORDAN, N.B. and WU, C.H., University of Wisconsin-Madison, Engineering Drive, Madison, WI, 53706, USA. **Abrupt Changes to Coastal Bluffs Adjacent to Coastal Structures: New Insights and Lessons Learned.**

Shore-parallel coastal structures (e.g., revetments) are commonly placed on shorelines in the Great Lakes to protect coastal infrastructure and property against bluff recession. Nevertheless, severe erosion of the beach and bluff toe at the flanks of structures is recognized but yet to be resolved. In this talk, we will reveal the coastal subaerial and subaqueous processes responsible for abrupt changes to beach and bluff erosion at the downcoast ends of structures in Ozaukee County, Wisconsin. Observations show that immediately downcoast of newly constructed revetments, bluff toe recession rates average 2.7 m/yr and beaches narrow from 8 m to less than 1 m wide. The nearshore and bluff toe steepen dramatically and sediment volume losses exceed 280 m3/m across the coastal bluff profile. Increased cumulative wave impact height, CWIH, caused by steepening of the nearshore and loss of beach-building processes, can accelerate undercutting of the bluff, changing failure mechanisms from rotational slope failures to translational failures, solifluction, and block failure. Overall the results of this integrated subaqueous hydrodynamics and subaerial bluff slope study provide valuable information to scientists and stakeholders facing urgent decisions regarding erosion management, shoreline protection, and coastal ecosystem health. *Keywords: Hydrogeomorphology, Coastal processes, Planning.*

JORGENSON, Z.G.[1], BRIGHAM, M.E.[2], ELLIOTT, S.M.[2], KIESLING, R.L.[2], MARTINOVIC-WEIGELT, D.[3], and SCHOENFUSS, H.L.[1], [1]St. Cloud State University, 720 Fourth Avenue S., St. Cloud, MN, 56301, USA; [2]U.S. Geological Survey, 2280 Woodale Drive, Mounds View, MN, 55112, USA; [3]University of St. Thomas, 2115 Summit Avenue, St. Paul, MN, 55105, USA. **Identifying Mixtures of Emerging Contaminants Representative of U.S. Great Lakes Tributaries.**

A study was initiated to evaluate the risks that emerging contaminants pose to Great Lakes fish and wildlife resources. Water samples were collected from 25 U.S. Great Lakes tributaries and embayments from 2010 to 2014 and analyzed for a broad suite of emerging contaminants. A chemical mixtures software was used to identify commonly occurring contaminant mixtures in sampled tributaries and to characterize representative mixtures for use in multi-generation fathead minnow laboratory exposures. More than 1,500 mixtures occurred in at least 25% of samples highlighting complex scenarios to which wildlife are exposed. To identify mixtures for use in laboratory exposures, a combination of multivariate statistics, the chemical mixtures software, and effects data from peer-reviewed literature were used. Multivariate statistics identified two distinct chemical groups interpreted to represent agricultural and urban influences. The chemical mixtures software was then used to identify sites where these representative mixtures occurred to determine appropriate concentrations for laboratory exposures. Results will be used to help further our understanding of how emerging contaminants interact as mixtures and their potential effects on fish resources. *Keywords: Emerging contaminants, Great Lakes Restoration Initiative (GLRI), Tributaries.*

JOUBERT, J.P., Bactest Ltd, Cambridge, ENGLAND. **The Light Is Green - Is This Thing On? On-Board, Integrated Ballast Water Testing.**

Transfer of invasive species in ballast water of ships prompted drafting of the IMO Ballast Water Management Convention, which will go into force on 8 Sept 2017 and require all ships to treat ballast water before discharging it. After treatment, ballast water must comply with regulated chemical, plankton and microbiological limits. To evaluate treatment efficiency, Port State Authority may send ballast samples to external laboratories, costing shipowners and authorities time and money. If samples fail, the ship may be fined or told to leave the port, thereby not being able to take on or offload cargo. On-board testing, enabling faster results while preserving sample integrity without time in transit is preferable. The Bactest Speedy Breedy SeaSure® is such a system. The only integrated ballast water monitoring system currently on the market, Speedy Breedy SeaSure® tests the microbiological quality of samples to numerical values within IMO-D2 standards. The system also features an optional chemical analysis unit and a fluorometer capable of testing in the required 10-50 µm range. Results from these 3 aspects of IMO-D2 compliance are collated by Speedy Breedy SeaSure® software, and reported in Ballast Log, an encrypted report, showing compliance or non-compliance, which can be sent securely via e-mail to applicable parties *Keywords: Ballast, Invasive species.*

JUDE, D.J.[1], HOLDA, T.J.[2], WATKINS, J.M.[2], BALCER, M.D.[3], and RUDSTAM, L.G.[2], [1]University of Michigan, Ann Arbor, MI, 48109, USA; [2]Cornell University, Ithaca, NY, 14850, USA; [3]University of Wisconsin Superior, Superior, WI, 54880, USA. **Trends in Mysis diluviana Abundance in the Great Lakes, 2006-2016.**

With the decline in Diporeia there is concern for a similar decline in Mysis diluviana as a result of lower primary productivity and/or increased predation by fish related to the loss of Diporeia as prey. In four lakes summer densities and biomasses from 2006 to 2016 were generally greater than spring densities. Population trends over the study period were mixed for lakes Ontario and Michigan, generally increasing for Lake Superior, while Lake Huron densities were way below those of the other lakes and almost an order of magnitude lower than in 1971. Mysis were collected in Lake Erie and there is likely a small self-sustaining population in the East Basin. Sizes of Mysis were dominated by two groups around 4 and 12 mm; the population was dominated by juveniles (ca. 60-80%), while males and females composed around 10% or less of the population; gravid females composed a small percentage (1-5%) of total numbers. Lake Superior with no mysis decline does not have large dreissenid mussel populations, nor large declines in Diporeia or changes in nutrient levels. Some combination of oligotrophication exacerbated by increased fish predation due to the decline in Diporeia appears to have lowered Mysis densities in the other three lakes, especially Lake Huron. *Keywords: Lake Michigan, Mysis, Lake Huron, Lake Ontario.*

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KALEJS, N.[1], HÖÖK, T.O.[1], ZISCHKE, M.[1], BEUGLY, J.S.[1], COLLINGSWORTH, P.[1], ROSEMAN, E.[2], and FIELDER, D.[3], [1]Department of Forestry and Natural Resources, Purdue University, West Lafayette, IN, USA; [2]Great Lakes Science Center, United States Geological Survey, Ann Arbor, MI, USA; [3]Alpena Fisheries Research Station, Michigan Department of Natural Resources, Alpena, MI, USA. **An Assessment of Reef Restoration Potential in Saginaw Bay, Lake Huron.**

Historically, Saginaw Bay had a complex of rocky reefs that functioned as preferred spawning habitat for various fish species, including Walleye (Sander vitreus) and Lake Whitefish (Coregonus clupeaformis). This reef system likely acted as a source of protection from egg predation, as well as of spawning diversity. Shifts in land usage and sedimentation led to the loss of nearly all reef structure in Saginaw Bay. In recent years, a decreased sedimentation regime has led to increased momentum towards reef restoration. The purpose of this study was to analyze spawning patterns of two key Great Lakes fish species, Walleye and Lake Whitefish, to determine whether current reproductive usage indicates potential for reef restoration. We evaluated four sites with varying levels of reef degradation. We analyzed water quality, substrate, sedimentation, reproductive usage, and egg deposition and predation. After completion of a two-year study, we have documented actively spawning Walleye and Lake Whitefish and egg deposition at multiple sites. However, densities of spawners and eggs were low and predation of both Walleye and Lake Whitefish eggs was documented in multiple fish species. We suggest that reef restoration may facilitate spawning success by attracting additional fish to spawn and providing crucial protection from egg predators. *Keywords: Fish populations, Lake whitefish, Habitats, Walleye.*

KANE, D.D.[1] and CHAFFIN, J.D.[2], [1]Defiance College, 701 N. Clinton St., Defiance, OH, 43512, USA; [2]Stone Laboratory, The Ohio State University, PO Box 119, Put-in-Bay, OH, 43456, USA. **YEAH BUOY?!? Monitoring cHABS in western Lake Erie using in-situ technology.**

The objective of this project was to determine how accurate data buoys are at monitoring for cHABs. Surface water samples (0-2 meter) were collected next to a data buoy located near Gibraltar Island throughout summers 2015 and 2016 and analyzed for total chlorophyll and with a FluoroProbe to determine cHAB-specific chlorophyll. Additionally, on a subset of dates water was collected at every meter throughout the water column to determine vertical position of cHAB at both the Gibraltar Island buoy and a buoy in the nearshore Sandusky subbasin. For the Gibraltar Island buoy, cHAB-specific chlorophyll concentration measured in surface water samples peaked in late July 2015 and had a very strong relationship with the buoy cHAB sensor. However, there was a weaker relationship between total chlorophyll and the buoy chlorophyll sensor. The every-meter sampling indicated that cHAB were spread evenly throughout the water column or increased in concentrations towards the surface. Relationships were not as strong for the Sandusky buoy and different temporal patterns of cHABs were evident. cHAB stratification led to a few inconsistencies between the buoy data and every-meter data that could potentially lead to inaccurate warnings and water treatment procedures. *Keywords: Buoys, Cyanobacteria, Harmful algal blooms, Fluoroprobe, Lake Erie.*

KANE, H.J., CHAPPAZ, A., and MCNAUGHT, A.S., Central Michigan University, Mount Pleasant, MI, 48859, USA. **Using Stable Isotopes to Determine the Effects of the Nearshore Shunt on the Lake Michigan Food Web.**

Since the introduction of benthic invasive species, many food webs throughout the Laurentian Great Lakes have been influenced by the nearshore shunt, a biological phenomenon likely caused by dreissenid mussel (*Dreissenida spp.*) hyperfiltration. The nearshore shunt is the shift of nutrients from the pelagic region to the benthic region, resulting in the movement of many pelagic taxa to the benthic region in search of nourishment. This investigation uses stable isotope analyses to measure the proportion of dreissenid mussels found in the diets of Lake Michigan fishes and invertebrates. In coordination with season, depth, and fish size, $^{13}C:^{12}C$ ($\delta^{13}C$) and $^{15}N:^{14}N$ ($\delta^{14}N$) ratios were used to evaluate the connectivity between pelagic and benthic regions of thirteen fish taxa and seven invertebrate taxa, including zooplankton, mysids, amphipods, chironomids, and crayfish. Preliminary results show that depth and season are important factors for characterizing the linkages between nearshore benthic regions and offshore pelagic regions. Additionally, a significant relationship between fish size and $\delta^{13}C$ was observed, suggesting frequent movement between pelagic and benthic regions. *Keywords: Dreissena, Nearshore shunt, Stable isotopes, Lake Michigan.*

KAO, Y.C.[1], BUNNELL, D.B.[2], and ROGERS, M.W.[3], [1]Michigan State University, Department of Fisheries and Wildlife, East Lansing, MI, USA; [2]USGS Great Lakes Science Center, Ann Arbor, MI, USA; [3]USGS Tennessee Cooperative Fishery Research Unit, Cookeville, TN, USA. **Not all great lake fisheries are equally great in response to climate and land use changes.**

Large lakes are important reserves of accessible freshwater and support human well-beings by providing ecosystem services such as fisheries, which support for livelihoods, nutrition, food security, and recreation in different parts of the world. In this study, we used a Bayesian network modeling approach to investigate effects of climate and land use changes, two emerging threats, on fisheries production across 30 large lakes in 5 continents, by analyzing historical fisheries harvests in 1970-2014. These 30 lakes were categorized by depth and food and water security levels, which are two factors influence the extent to which climate or land use changes affect fisheries production. The Bayesian network model is structured to represent how climate and land use variables in the watershed can affect biological and environmental variables in the lake, and consequently affect fisheries harvest, with adjustments to fishing effort and enhancement stocking. Results from this study will have implications for identifying lakes that are most vulnerable to climate and land use changes, which is needed information for organizations such as the Food and Agriculture Organization of the United Nations that are charged with ensuring sustainable fisheries for food security and human welfare. *Keywords: Climate change, Land use, Fisheries, Watersheds.*

KAO, Y.C.[2], BUNNELL, D.B.[1], and ROGERS, M.R.[3], [1]Michigan State University, Department of Fisheries and Wildlife, East Lansing, MI, USA; [2]USGS Great Lakes Science Center, Ann Arbor, MI, USA; [3]USGS Tennessee Cooperative Fishery Research Unit, Cookeville, TN, USA. **The relative importance between round goby and alewife effects on Lake Michigan salmonines.**

Round goby has become pivotal in food webs across the Great Lakes and may have impacted salmonine fisheries in Lake Michigan. We used an Ecopath with Ecosim model to assess the relative importance between alewives and round goby to Chinook salmon, lake trout, and steelhead in Lake Michigan in the period of 2002-2014. Results showed that the biomass and mortality rates of round goby have been comparable to or higher than those of alewives since 2007, suggesting that round goby have become an important prey to predators in the food web. Correspondingly, the keystoneness of round goby, an indicator for identifying species with low biomass but a strong structuring role in the food web, has increased over time and become higher than the keystoneness of alewives since 2007. Simulated diet compositions showed that different salmonines responded to the shift in prey base differently. We set all three salmonines have less than 5% round goby in diets in 2002 as initial conditions but in 2014, simulated diets of lake trout and steelhead both had more than 50% round goby while simulated Chinook salmon diets remained almost unchanged. Overall, our results showed that round goby may have reshaped salmonine fisheries as lake trout and steelhead may be better adapted to a food web with large round goby biomass than Chinook salmon. *Keywords: Round goby, Food web, Salmon, Lake Michigan.*

KARATAYEV, A.Y.[1], KARATAYEV, V.A.[2], BURLAKOVA, L.E.[1], MEHLER, K.[1], and CLAPSADL, M.[1], [1]Great Lakes Center, Buffalo State College, 1300 Elmwood Ave, Buffalo, NY, 14222, USA; [2]Department of Environmental Science and Policy, University of California, Davis, CA, USA. ***Dreissena* Growth Variation in Time and Space: Lessons from Lake Erie.**

To determine the growth rates of quagga mussels under different conditions two sets of experiments were conducted in 2015 and 2016 in littoral and profundal zones of the eastern basin of Lake Erie. Individually marked mussels were kept in cages from May to November - December. In addition, newly settled young-of-the-year *Dreissena* were collected from the mooring system at the end of experiments, counted and measured. We found a strong gradient in dreissenid recruitment and growth with increasing depth, following declines in food availability and temperature. Low growth and high mean size imply much higher survival, longevity, and much lower productivity of mussels in deep vs. shallow areas. This implies that the bulk of dreissenid biomass in deep profundal zone of eastern basin of Lake Erie and possibly other deep lakes or lake basins has very limited ecological impacts on pelagic resources compared to mussels in shallower warmer areas that have high growth and production and therefore higher ecosystem impacts. At the same time, this result explains the slower dynamics exhibited by profundal dreissenid populations in the Great Lakes. Similarly, experimental results and long-term monitoring suggest a lack of recruitment in profundal areas driven by food depletion during summer stratification. *Keywords: Lake Erie, Exotic species, Dreissena.*

KARBOSKI, C.T., GORSKY, D., BIESINGER, Z., and BRUESTLE, E., U.S. Fish and Wildlife Service, 1101 Casey Road, Basom, NY, 14013, USA. **Lake Trout Behavior and Habitat Preference in Lake Ontario.**

Lake Trout *Salvelinus namaycush* are an ecologically and economically important native species in Lake Ontario. Overfishing and invasive species introductions drove them to near extirpation. Recovery of Lake Trout in Lake Ontario has been difficult with few successes, however in recent years there has been evidence of natural reproduction throughout the lake. Little is known about the behavior of Lake Trout due to the inherent difficulty in collecting data on them at depth in the Great Lakes. We used pop off satellite tags to track

Lake Trout behavior and habitat preference in Lake Ontario. Trout were tagged in April 2015 with half of the tags releasing after the summer and half releasing in May 2016. We observed regular diel patterns in activity level, differences in behavior seasonally and changes in habitat preference throughout the year. Gaining knowledge about their depth and habitat selection is key to understanding their role in the predator prey balance of the system. *Keywords: Fish behavior, PSATs, Lake trout, Lake Ontario.*

KASHIAN, D.R.[1], BOEGEHOLD, A.G.[1], ALAME, K.[1], and JOHNSON, N.S.[2], [1]Wayne State University, Detroit, MI, USA; [2]USGS, Great Lakes Science Center, Millersburg, MI, USA. **Effects of cyanobacteria on quagga mussel (*Dreissena rostriformis bugensis*) reproduction.**

Dreissenid mussels are successful invaders in a wide variety of aquatic environments; yet, their populations maybe regulated by Harmful Algal Blooms (HABs) through several reproductive mechanisms including spawning and fertilization. We investigated the impacts of several bloom forming cyanobacteria species on Dreissenid reproduction through a series of bioassays examining quagga mussel fertilization and sperm motility. Sperm motility was calculated by recording the movement of sperm from five males per treatment at 400X, tracking velocity and distance traveled. Fertilization success was determined through assays combining quagga mussel eggs and sperm in individual vials containing cyanobacteria cultures (n=5), and enumerating zygote formation marked by cellular cleavage. For all assays, controls of artificial lake water were used. Cyanobacteria species inhibited reproductive endpoints; sperm motility was reduced by *Aphanizomenon flos-aquae* and two strains of *Microcystis aeruginosa* and fertilization rates decreased with exposure to five unique species of cyanobacteria including two strains of *M. aeruginosa* ($p<0.05$). These results show that HABS may negatively impact Dreissenid populations. Understanding the mechanism by which HABS disrupts reproduction may inspire new dreissenid control tactics. *Keywords: Harmful algal blooms, Reproduction, Zebra mussels.*

KAST, J.B.[1], ALOYSIUS, N.[1], KALCIC, M.M.[1], ARNOLD, G.[2], and MARTIN, J.F.[1], [1]Department of Food, Agricultural and Biological Engineering, The Ohio State University, Columbus, OH, 43210, USA; [2]The Ohio State University Extension, Columbus, OH, 43210, USA. **Modeling the Impact of Manure Application Practices: Phosphorous Discharge from the Maumee Watershed.**

Harmful Algal Blooms (HABs) occurring in Lake Erie's Western basin have created numerous environmental and economic problems from forcing the closure of a Toledo drinking water plant in 2014 to inhibiting local tourism. In response to these blooms the most recent Great Lakes Water Quality Agreement Annex 4 called for a 40% reduction in both total phosphorous (TP) and dissolved reactive phosphorous (DRP). To meet phosphorous reduction targets, nonpoint sources of phosphorous from key watersheds such as the predominantly agricultural based Maumee River watershed must be decreased. Specifically, nutrient management plans of all fertilizer types, including manure, must be formulated in order for agricultural producers to maintain crop yields while protecting the water quality of Lake Erie and tributaries. To evaluate different manure application practices within the watershed a SWAT model was used. Practices that were analyzed focused on the effects of broadcasting versus incorporating manure and include scenarios of manure application in the fall, manure application in the summer after wheat harvest, and manure application on growing corn and wheat. Results indicate how differing manure application methods affect TP and DRP discharge from the watershed. *Keywords: SWAT, Lake Erie, Harmful algal blooms.*

KASTER, J.L. and KLUMP, J.V., University of Wisconsin-Milwaukee, School of Freshwater Sciences, 600 East Greenfield Avenue, Milwaukee, WI, 53204, USA. **Reintroduction of *Hexagenia* to Green Bay, Lake Michigan.**

Pollution in lower Green Bay, Lake Michigan over the past century was evidenced by the local extirpation of *Hexagenia* (primarily *H. limbata*) mayflies. The last *Hexagenia* was collected from Green Bay in 1955; however, the latter 20th and early 21st century remediation efforts to improve water quality of the Bay should ultimately facilitate reestablishment of the mayfly population. Approximately 488 million eggs were stocked in three cohorts (2014, 2015, 2016) at lower Bay study sites, including the Area of Concern (AOC). The first adult *Hexagenia* emergence occurred in June, July, and August 2016. This was the first emergence in the lower bay recorded since the 1950s. Adult exuviae were collected from Sawyer Bay (in Sturgeon Bay), Little Sturgeon Bay, Little Tail Point, and from the Green Bay AOC at Long Tail Point. The largest exuviae counts along west shore of Potawatomi Island averaged 95/100m of shoreline; however, the main hatch was presumably not observed. The second filial generation offspring originating from natural fertilization were viable as fertile eggs and capable of hatching as neonates. This suggests that the *Hexagenia* population is sustainable across generations and that "stocked" populations can be established and maintained if natural reproductive thresholds are achieved. *Keywords: Benthos, Hexagenia, Indicators, Green Bay.*

KATONA, L.R.[1], FAZEKAS, H.M.[1], BROTHERS, S.M.[2], SIBLEY, P.K.[2], and VADEBONCOEUR, Y.[1], [1]Wright State University, 3640 Colonel Glenn Hwy., Dayton, OH, 45435, USA; [2]University of Guelph, 50 Stone Road East, Guelph, ON, N1G 2W1,

CANADA. **Littoral benthic primary production in Western Lake Erie and Georgian Bay, Lake Huron.**

Benthic primary production has rarely been measured in the Laurentian Great Lakes. Our published models predict that attached algae can contribute appreciably to whole-basin primary production in areas with extensive littoral zones and high water clarity such as Georgian Bay. Rapid water column light attenuation combined with wave disturbance in Lake Erie's Western Basin may constrain habitat for attached algae, limiting their contribution to whole-lake primary production. We measured benthic primary productivity on rocks and sediments in the Western Basin of Lake Erie and Georgian Bay of Lake Huron in summer 2016. Light-saturated primary production (Pmax) on rocks in Lake Erie increased with depth, from 10 - 500 mg C $m^{-2}h^{-1}$ at 0.5 and 3 m. Pmax for Lake Erie sediments was <10 mg C $m^{-2}h^{-1}$ at depths <5 m. In Georgian Bay Pmax on rocks ranged from 21 - 40 mg C $m^{-2}h^{-1}$ at 0.5 and 8 m while Pmax on sediments collected from 1.5 m averaged 60 mg C $m^{-2}h^{-1}$. We combined these rates with photosynthesis-irradiance curves collected using a Pulse Amplitude Modulated fluorometer to estimate whole-basin primary production in Western Lake Erie and Georgian Bay. Our results illustrate the impacts of light and wave exposure on Great Lakes benthic producers. *Keywords: Productivity, Periphyton, Littoral zone.*

KEELER, K.M., University of Toledo, 2801 W. Bancroft, Toledo, OH, 43606, USA. **Great Lakes Bowls and Bioenergetics: Experiences Across Outreach and Research.**

Across academic research, career endeavors, and educational outreach, Jim Diana has left an incredible long standing mark in an incredibly short amount of time for one person hailing from the state to the south. Highlights will draw from graduate experience at the University of Michigan from 2011-2013 while researching bioenergetics and the role Great Lakes preyfish have in controlling invasive zooplankton, transitioning into new research within the St. Clair-Detroit River System where Jim has championed numerous projects, and lastly educational outreach. In 2012, the Great Lakes Bowl, a regional competition of the National Ocean Sciences Bowl, became an addition to the education component of Michigan Sea Grant. Three of Jim's students became coordinators for the event in its inaugural year and created a legacy of involvement by University of Michigan graduate students ever since. After 5 years of Michigan Sea Grant direction, over 500 teachers and students have participated in the Great Lakes Bowl, several of whom have gone on to enrollment at the University of Michigan pursuant of STEM careers. *Keywords: Invasive species, Bythotrephes longimanus, Outreach, Lake Michigan, Bioenergetics, Lake Superior.*

KEELER, K.M.[1], ROSEMAN, E.F.[2], KOK, S.[3], DROUILARD, K.G.[4], and MAYER, C.M.[1], [1]University of Toledo, 2801 W. Bancroft, Toledo, OH, 43606, USA; [2]US Geological

Survey-Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105, USA; [3]Environment Canada, 867 Lakeshore Rd, Burlington, ON, L7T 3M3, CANADA; [4]University of Windsor, 401 Sunset Ave,, Windsor, ON, N9B 3P4, CANADA. **From Nearshore to Offshore: A Comparison of Zooplankton Taxa within the Detroit River.**

A common analysis within large aquatic ecosystems is the comparison of nearshore to offshore taxa assemblages. This is no different within the Laurentian Great Lakes where abundance and distribution gradients are typically studied for multiple taxa and trophic levels ranging from phytoplankton and zooplankton, to all life-stages of fish. However, due to their general narrow size and hydrologic characteristics, river systems are rarely studied for this same complexity. The international Detroit River is a conduit of zooplankton productivity connecting Lake St. Clair and Lake Erie while also providing important prey resources for native fishes in nearshore nursery habitat. Herein, we examined the differing zooplankton taxa structure of southern Lake St. Clair and the Detroit River from summer through fall 2015. Comparisons of nearshore to offshore zooplankton assemblages were made from collections across 7 Lake St. Clair and 14 (upper and lower) Detroit River sites during June, September, and November. Analysis of the zooplankton community in these less scrutinized habitats provides important information on fluctuations of productivity gradients within the river. Information disseminated will also be vital to the restoration framework of the Detroit River and applicable to other Great Lakes connecting channels. *Keywords: Zooplankton, Detroit River.*

KEELER, K.M.[1], FISCHER, J.L.[1], PROVO, S.[1], DEBRUYNE, R.[1], MAYER, C.M.[1], BRIGGS, A.S.[2], BOASE, J.C.[2], HESSENAUER, J.M.[3], THOMAS, M.V.[3], WEHRLY, K.E.[3], WILLS, T.C.[3], ROSS, J.E.[4], MIFSUD, D.[5], STAPLETON, M.[5], GREENWALD, K.R.[6], SUTHERLAND, J.L.[6], BOWSER, D.A.[7], IRELAND, S.A.[7], GALASSINI, E.A.[7], JACKSON, S.A.[7], KENNEDY, G.[7], and ROSEMAN, E.F.[7], [1]University of Toledo, Toledo, OH, USA; [2]US Fish and Wildlife, Ann Arbor, MI, USA; [3]Michigan Department of Natural Resources, Harrison Twp., MI, USA; [4]Ashland Fish and Wildlife, Ashland, WI, USA; [5]Herpetological Resource and Management LLC, Chelsea, MI, USA; [6]Eastern Michigan University, Ypsilanti, MI, USA; [7]US Geological Survey-Great Lakes Science Center, Ann Arbor, MI, USA. **Minnows, Madtoms, and Mudpuppies: Sensitive Species in Restored Habitats.**

Historical degradation of aquatic habitats in the St. Clair-Detroit River System due to excessive nutrient inputs, contaminants, wetland draining, channelization, and shoreline hardening led to the designation of habitat-related beneficial use impairments within both rivers' Areas of Concern. Many habitat restoration projects have been completed to address these impairments, along with post-construction monitoring. There are several sensitive

species that have served as effective biological indicators and reflect the success of habitat restoration efforts. Fish species include Northern Madtom (*Noturus stigmosus*), Pugnose Shiner (*Notropis anogenus*), and Pugnose Minnow (*Opsopoeodus emiliae*), and the amphibious salamander, the Mudpuppy (*Necturus maculosus*). Highlights will focus on the application of a multi-agency assessment approach and its utility for quickly surveying the distribution and relative catch-per-effort of the aforementioned bioindicator species. Combined measures of relative abundances, collections of multiple life history stages previously undocumented, and expanded geographic distributions indicate the continued improvements occurring in this connecting channel while supporting the species recovery among numerous other aquatic organisms. *Keywords: Amphibians, St. Clair River, Fish, Detroit River, Great Lakes Restoration Initiative (GLRI).*

KELPINSKI, J., MDARD, Lansing, MI, 48909, USA. **Farmers choose MAEAP to Protect Water Quality.**

The Michigan Agriculture Environmental Assurance Program (MAEAP) brings together training, risk assessment, technical assistance, engineering, cost-share, and agency verification in an industry-led partnership for pollution prevention. This partnership of organizations is dedicated to helping Michigan's farmers protect the environment in a way that is performance based and cost effective. It is a legislated certainty program with incentives to become verified under the program. The risk assessments help identify environmental concerns associated with farmstead sites, crop production, and livestock production. Michigan leads the nation in on-farm risk assessments with almost 8,300 conducted over past 8 years. Conservation practices are designed to be cost-effective, address identified risks and are consistent with applicable environmental regulations and agency standards. In the Western Lake Erie Basin from FY13-FY16, MAEAP verifications have resulted in the reduction of 201,494 tons/year of sediment and 337,191 pounds/year of phosphorous. Approximately 16.8% of the Michigan WLEB acreage is MAEAP verified and operating with a nutrient management plan. This is up from 12.2% in FY15 (37% increase). Once verified, these farms commit to continuing the environmental practices and are re-verified are re-verified after 5 years. *Keywords: Conservation, Watersheds, Risk assessment.*

KENNEDY, G.[1], ROSEMAN, E.F.[1], CHIOTTI, J.A.[2], SCHMIDT, B.A.[2], BOWSER, D.A.[1], CRAIG, J.[1], and DEBRUYNE, R.[3], [1]US Geological Survey, Great Lakes Science Center, Ann Arbor, MI, 48105, USA; [2]US Fish and Wildlife Service, Alpena Fish & Wildlife Concervation Office, Waterford, MI, 48327, USA; [3]University of Toledo, Dept. of Environmental Sciences, Toledo, OH, 43606, USA. **Use of a New Artificial Reef as Spawning Habitat by Lake Sturgeon in the Detroit River.**

Historically, lake sturgeon (*Acipenser fulvescens*) were abundant in the St. Clair - Detroit River System (SCDRS). However, by 1925 the removal of river bottom substrates greatly reduced spawning habitat and contributed to the decline of lake sturgeon populations in these rivers. To restore functional fish spawning habitat, several reefs (0.1-1.6 ha) have been constructed throughout the SCDRS. Here we examine pre- and post-construction monitoring efforts for egg deposition and larvae at the newest reef (Grassy Island, Detroit River) to determine if lake sturgeon are using the reef for spawning. Eggs were sampled using egg mats and larvae were sampled during nocturnal drift with benthic D-frame nets and depth-stratified conical nets deployed upstream and downstream of the reef. No eggs were collected at reference sample sites prior to construction; however eggs were collected on the new reef material during the spring 2016. Examination of larval drift collections downstream of the reef show successful incubation and hatch of the eggs deposited on the reef, indicating that the reef is providing functional spawning habitat for lake sturgeon. Thorough pre- and post-monitoring provides information critical to the adaptive management approach to restoration and to aid the recovery of lake sturgeon in the SCDRS.
Keywords: Detroit River, Lake sturgeon, Restoration.

KERFOOT, W.C.[1], HOBMEIER, M.M.[1], MAKI, R.P.[2], LEDUC, J.F.[3], HIRSCH, J.K.[4], and STAPLES, D.F.[5], [1]Great Lakes Research Center, Michigan Technological University, 1400 Townsend Drive, Houghton, MI, 49931, USA; [2]Voyageurs National Park, 415 S. Pokegama Avenue, Grand Rapids, MN, 55744, USA; [3]Voyageurs National Park, 360 E. Hwy 11, International Falls, MN, 56649, USA; [4]Minnesota Department of Natural Resources (MN DNR), 500 Lafayette Road, Box 25, St. Paul, MN, 55155-4025, USA; [5]Minnesota Department of Natural Resources (MN DNR), 5463-C W. Broadway, Forest Lake, MN, 55025, USA. **Plague of Waterfleas (Bythotrephes): Impacts Cascade From Microcrustaceans to Planktivorous Fish.**

The spiny cladoceran (*Bythotrephes longimanus*) is expanding from Great Lakes coastal waters into inland lakes within a northern latitudinal belt. In a large, Boundary Water lake complex (Voyageurs National Park), we used 2-year spatial and 12-year temporal comparisons to quantify seasonal impacts on food webs, biomass, and secondary production. *Bythotrephes* severely depressed microcrustaceans during summer and early fall, when the predator was most abundant. Cladoceran and cyclopoid copepods suffered the most serious declines, although the resistant cladoceran *Holopedium* was favored in spatial comparisons. Microcrustacean biomass was reduced 40-60% and secondary production declined by about 67%. Decline in secondary production was due both to summer biomass loss and to longer generation times of calanoid copepods. We recently confirmed reduced planktivorous fish growth (perch) in two of the largest lakes (Kabetogama, Rainy Lakes) relative to a nearby control lake (Vermillion Lake) which lacked *Bythotrephes*. The large-lake Boundary complex, uncompromised by mussel effects, gives insight into changes now playing out in the Great Lakes and Lake Champlain. Because resting eggs pass through fish guts intact, MDNR mitigation measures include boat live well, minnow bucket, and fish transfer restrictions. *Keywords: Invasive species, Bythotrephes, Fish.*

KERKEZ, B., University of Michigan, CEE, 2350 Hayward St, 2372 GGB, Ann Arbor, MI, 48109, USA. **Toward the autonomous management of water quality thorough real-time sensing and control.**

The need to improve urban water quality is calling for an increasing portfolio of options that are available to managers. One such option relies on information technology. Rather than building costly new infrastructure, it is possible to equip urban storm and sewer systems with sensors and controllers (pumps, gates, valves, etc). By controlling these assets based on sensor data, infrastructure can effectively be repurposed in real-time to reduce flooding and guide watershed-scale treatment of non-point source runoff. Given the nascent nature of this idea, no or few models exist to model real-time stormwater control at the scale of cities. Furthermore, few tools have been developed to allow decision makers to compare these new technological tools to traditional solutions. Here, we present a new modeling framework to allow for real-time controlled stormwater systems to be simulated using coupled physical flow, quality and control sub-models. We also discuss how this new modeling framework is being used across numerous real-world sites in Great Lakes watersheds to guide the real-time control of urban water quality. *Keywords: Water quality, Monitoring, Modeling.*

KESSEL, S.T.[1], HONDORP, D.W.[2], HOLBROOK, C.M.[3], and KRUEGER, C.C.[4], [1]Michigan State University, East Lansing, MI, USA; [2]USGS, Ann Arbor, MI, USA; [3]USGS, Millersburg, MI, USA; [4]Michigan State University, East Lansing, MI, USA. **Movement behavior variability within a lake sturgeon (Acipenser fulvescens) population.**

Population structure, distribution and dispersal arguably underpin the entire field of animal ecology, with consequences for both regional species persistence and ecosystem services. This study investigated these elements for lake sturgeon (*Acipenser fulvescens*) centered around the Huron Erie Corridor (HEC) in the Laurentian Great Lakes, defining two overlapping metapopulations with a high level of intraspecific behavior dimorphism. Between 2011 and 2016, the movements of 268 lake sturgeon tagged in the HEC were continuously monitored across broader Great Lakes region through the use of acoustic telemetry. This reveled that two metapopulations to inhabit the HEC, one centered around the Detroit River and the other around the St Clair River. Both metapopulations exhibited partial migration in addition to migratory dimorphism. Five distinct movement strategies common to both metapopulations, one resident and four migratory, were described through hierarchical cluster analysis, with 14 total subgroups base on regional spatial use. Group assignment was not explained by size or sex, with all groups comprised of biologically similar individuals and sex proportions. Spatial overlap of the intrapopulation divergent movement groups suggest a contingent structure to both metapopulations. *Keywords: St. Clair River, Lake sturgeon, Detroit River, Telemtry, Spatial analysis.*

KESSLER, J.A.[1], WANG, J.[2], MANOME, A.F.[1], and CHU, P.[2], [1]Cooperative Institute for Limnology and Ecosystems Research, 440 Church Street, Ann Arbor, MI, 48109, USA; [2]Great Lakes Environmental Research Laboratory, 4840 S State Rd, Ann Arbor, MI, 48108, USA. **Modeling the Great Lakes with FVCOM+UGCICE.**

In this study, the Finite Volume Community Ocean Model (FVCOM) is fully-coupled with an unstructured-grid version of the Los Alamos sea ice model Community Ice CodE (CICE). These models are used to simulate a 15 year hindcast period of lake conditions in the Great Lakes Basin. State variables such as temperature and fractional ice cover are validated with both satellite and in-situ observations as a means of gauging the skill of this modeling framework. The modeled ice cover generally agrees with observed ice cover. However in some years, the model appears to under-predict lake ice and the cause for this is investigated. *Keywords: Ice, Modeling, Lake model.*

KIBLER, R.J., XUE, P., and YE, X., Michigan Technological University, 1400 Townsend Dr., Houghton, MI, 49931, USA. **Understanding Lake Superior Warming through Observational Data and Model Results.**

Despite vast research regarding the Great Lakes region, consistent hydrodynamic modeling of the Great Lakes has still not been perfected. Over the past decade, studies have been published investigating the impacts of climate change on Lake Superior. Several studies have focused on summer warming and have concluded that Lake Superior's summer surface water temperature is warming at a rate twice as fast the surrounding region's air temperature over the past 30 years. However, there has been far less research on the impacts of climate change on winter warming partly due to the lack of observations. In this study, several data sets and model results are utilized to examine the changing heat content of Lake Superior. Results show that the winter warming is comparable to the summer in terms of heat content, suggesting it is a more representative method to define warming in Lake Superior. *Keywords: Hydrodynamic model, Climate change, Lake Superior.*

KIESLING, R.L.[1], RENEAU, P.C.[2], FITZPATRICK, F.A.[2], and GROTEN, J.T.[1], [1]USGS MN Water Science Center, 2280 Woodale Drive, Mounds View, MN, 55113, USA; [2]USGS WI Water Science Center, 8505 Research Way, Middleton, WI, 53562, USA. **Effects of tributary inflows on water, sediment, and nutrient budgets in the St. Louis River Estuary.**

Flows, sediment, and nutrient fluxes in the St. Louis River Estuary (SLRE) are affected by inflows from multiple tributaries as well as by water exchanges with Lake Superior through two connecting ship entries. Five index-velocity gages were installed in 2015 to continuously monitor water levels, flows and velocity profiles in the SLRE. Sediment and nutrient concentration data also were collected at gages to support calculation of nutrient and sediment loads. Water budget calculations for 2016 indicate significant contributions to the water balance from the St. Louis, Nemadji and Pokegama Rivers as well as from the SLRE tributaries in the vicinity of Duluth, MN. High flow events from tributaries in 2016 produced brief synchronous discharge peaks out of the two connecting channels into Lake Superior. However, the patterns of outgoing flow from the estuary to the nearshore quickly changed to a mixture of inflows of lake water through the Duluth Entry and combined river outflows through the Superior Entry. These initial observations of changing flow directions during storm events illustrate the critical need for monitoring constituent concentrations and velocities in both entries in order to adequately calculate the net flux of water, sediment, and nutrients from the SLRE to the nearshore of Lake Superior.
Keywords: Estuaries, Hydrologic budget, Lake Superior.

KIM, D.K.[1], DONG, F.[1], NEUMANN, A.[1], MUGALINGAM, S.[2], and ARHONDITSIS, G.B.[1], [1]University of Toronto, Toronto, CANADA; [2]Lower Trent Conservation, Trenton, CANADA. **Determination of the best management practices in the Napanee River watershed using SWAT.**

The main objective of our research is to apply SWAT to determination of the best management practices. Our modelling focus is on the Bay of Quinte AOC located in the north-eastern part of Lake Ontario. Several empirical evidences have explicitly accounted for the impact of extreme rainfall events on phosphorus inflow to the Bay during the growing season. In this respect, the SWAT model aims to assess the fate and transport of phosphorus at a high temporal resolution in the Napanee River watershed which is part of the Bay of Quinte basin. Subsequently, we evaluated a variety of disturbances associated with extreme events and land-use alterations. Our modelling study offers new insights into establishing optimal strategies for best management practices by characterizing "hot-spots" of phosphorus export in relation to episodic rainfall events. Finally, the ultimate goal of this project is to develop an integrated watershed-receiving waterbody modelling framework for

the Bay of Quinte AOC that will shed light on the factors that determine the present state of "Eutrophication or Undesirable Algae" (Beneficial Use Impairment #8) and the future progress with delisting the Bay of Quinte AOC.

KIMBROUGH, K.L.[1], DAVENPORT, E.[1], EDWARDS, M.[1], JOHNSON, W.E.[1], JACOB, A.P.[2], CHANDRAMOULI, B.[3], GRACE, R.[3], and RINGWOOD, A.[4], [1]NOAA, National Ocean Service, Silver Spring, MD, 20910, USA; [2]CSS-Dynamac, Fairfax, VA, 22030, USA; [3]SGS AXYS, British Columbia, V8L5X2, CANADA; [4]UNC-Charlotte, Charlotte, NC, 28223, USA. **Great Lakes Mussel Watch: Initiation of Effects-based Monitoring of Contaminants of Emerging Concern.**

Under the ongoing Great Lakes Action Plan II, NOAA's National Centers for Coastal Ocean Science Mussel Watch Program (MWP) has initiated monitoring Contaminants of Emerging Concern (CEC) and assessment of the effects of these compounds on mussel health. Because most CECs are hydrophilic, and therefore do not accumulate in tissues, effects based monitoring approaches are essential. An experimental study to monitor a broad suite of CECs and associated effects on mussel health using cellular biomarkers and metabolomics was conducted at Maumee River in 2015 and 2016. Polar Organic Chemical Integrative Sampler (POCIS) was co-deployed at a subset of sites, which allows the comparison of environmental detection with CEC uptake in mussels. Relevant results from this two-year study will be presented. The enhanced efforts of Great Lakes MWP are achieved through numerous collaborations and partnerships with other federal, state, local agencies and academic institutions. *Keywords: Monitoring, Contaminants of emerging Concern, Mussels.*

KINDERVATER, E.A. and STEINMAN, A.D., Annis Water Resources Institute- Grand Valley State University, 740 W. Shoreline Drive, Muskegon, MI, 49441, USA. **Phosphorus Retention in West Michigan Two-stage Agricultural Ditches.**

Excess nutrients entering a water body contribute to eutrophication and can negatively impact ecological structure and function, as well as the economic vitality of surrounding communities. For example, phosphorus (P) and sediment inputs from agricultural drainage have facilitated the development of hypereutrophic conditions in Lake Macatawa, a drowned river mouth lake located in Holland, Michigan. Two-stage ditches (TSDs), an agricultural best management practice, are being installed in the watershed to help capture nutrients and sediment. TSDs are known to effectively remove nitrogen through denitrification but less is known about their ability to retain P. This project assesses how effective TSDs are at retaining P compared to corresponding upstream, traditional ditches within the Macatawa watershed. Results show that sediments are the major sink of P

in these systems despite variation in total sediment P (TP). TP tended to be higher in the traditional reach compared to the two-stage reach. The most abundant P fraction varied among study ditches. Equilibrium P concentration values suggest sediment was a sink for P in one ditch but a source of P in another ditch. The differences between ditches could be due to age and sediment type. Results will be used to inform management decisions within the watershed. *Keywords: Phosphorus, Agriculture, Sediments.*

KINDREE, M.M.[1], JONES, N.E.[2], and MANDRAK, N.E.[1], [1]University of Toronto Scarborough, 1265 Military Trail, Toronto, ON, M1C 1A4, CANADA; [2]Ontario Ministry of Natural Resources and Forestry-Trent University, 2140 East Bank Drive, Peterborough, ON, K9J 7B8, CANADA. **Modelling Freshwater Fish Distributions in the Canadian Great Lakes Basin.**

The Great Lakes basin is the largest freshwater ecosystem on Earth and provides habitat for over 200 fish species. The aquatic biodiversity of this region is threatened due to habitat degradation and loss caused by anthropogenic practices and aquatic invasive species (AIS). While fish species distribution database compilation and modelling has been conducted in the American portion of the Great Lakes basin since the mid-1990s under the Great Lakes Aquatic GAP project, knowledge of species distributions in the Canadian portion is incomplete. Landscape-based distribution models will be used to fill the knowledge gaps in Canadian fish distributions, particularly species at risk (SAR) and AIS. Well-established and novel statistical techniques will be used to elucidate species-environment relationships at the local (watershed) and regional scale for each fish species within the basin. This will also allow for the evaluation of the efficacy of each model in predicting fish distributions within the Canadian Great Lakes region. Linking species requirements to habitat features at the landscape scale is imperative in species management and conservation planning by identifying critical habitat for SAR and potential areas for reintroduction, and identifying areas of significant risk to invasive species introductions. *Keywords: Fish, Distribution patterns, Great Lakes basin.*

KING, N.R.[1], EMBKE, H.[1], KOCOVSKY, P.M.[2], MAYER, C.M.[1], and QIAN, S.S.[1], [1]University of Toledo, 2801 W. Bancroft St., Toledo, OH, 43606, USA; [2]US Geological Survey, Sandusky, OH, USA. **Fish use chronology of the Sandusky River to inform Grass Carp management actions.**

Invasive Grass Carp (Ctenopharyngodon idella) have been stocked for decades in the United States for vegetation control. Grass Carp have the ability to consume large amounts of aquatic vegetation and therefore can have adverse effects on ecosystems. Natural reproduction in the Sandusky River was confirmed in 2015 when viable grass carp eggs were

captured. We sampled larval fish using bongo nets and larval light traps June-August of 2015 and 2016 to determine which species utilize the river during the Grass Carp spawning period. The largest proportions of individuals collected were from the families Cyprinidae, Centrarchidae, and Clupeidae. Understanding when and which species inhabit the river can inform which non-target fish may be affected during Grass Carp management actions. *Keywords: Fish management, Invasive species, Lake Erie.*

KIRETA, A.R., SAROS, J.E., and MCGILL, B.J., Climate Change Institute, University of Maine, Orono, ME, 04669, USA. **Assessing Lake Superior Planktonic Diatom Distribution: Improving Paleolimnological Interpretations.**

We use a decade of modern summer monitoring data to investigate relationships between environmental variables and 4 diatom species common in Lake Superior sediment records. These taxa respond to climate change in smaller lakes. Two diatom species appear to have relationships with climate-driven forcing and water chemistry measures in Lake Superior: The *Discotella stelligera* complex and *Lindavia comensis*. The *D. stelligera* complex decreases in abundance with increasing turbidity, which may be analogous to associations with high light levels found in previous research. *L. comensis* is related to decreasing thermocline depth and increasing turbidity, which may be analogous to moderate stratification found in other lakes. Both taxa were also related to multiple water chemistry measures, supporting complex, interactive drivers of phytoplankton abundance. Our results suggest limited climate effect on distributions of *L. bodanica* and *L. ocellata*, which were adequately explained by nutrients and indicate diatom response to climate-driven forcing may not be as clear in Lake Superior as in smaller lakes. We also present results from a paleolimnological record during the Medieval Climate Anomaly (MCA, 950-1250 CE), a past warming period, for the two diatoms related to climate. *Keywords: Climate change, Paleolimnology, Diatoms.*

KITSON, M.[1], HAGLEY, C.A.[1], KLINE, K.S.[2], GUTSCH, M.[3], KIEFER, V.[4], BYERS, C.[5], and HUPPERT, M.[6], [1]Minnesota Sea Grant, 31 West College Street, Duluth, MN, 55812, USA; [2]Wisconsin Sea Grant, 1975 Willow Drive, Madison, WI, 53706, USA; [3]University of Minnesota, 1035 Kirby Drive, Duluth, MN, 55182, USA; [4]East Carolina University, 302 E. 9th Street, Greenville, NC, 27858, USA; [5]Rosholt Middle School, 346 Randolph Street, Rosholt, WI, 54473, USA; [6]Menomonie High School, 1715 5th Street West, Menomonie, WI, 54751, USA. **Using Mentoring Aboard a Tall Ship to Foster a Great Lakes Education Community of Practice.**

The Center for Great Lakes Literacy (CGLL) is a collaborative effort led by Sea Grant educators throughout the Great Lakes watershed. The Center increases Great Lakes literacy among an engaged community of educators, scientists and citizens by providing hands-on experiences, educational resources and networking opportunities that foster informed and responsible decision-making and advances basin-wide stewardship. In August 2016, educators from Minnesota and Wisconsin Sea Grant collaborated to pilot a new shipboard science workshop, building on CGLL's success with a professional development workshop for educators aboard the USEPA R/V *Lake Guardian.* As part of the Tall Ships Duluth Festival, 12 Minnesota and Wisconsin educators sailed from Milwaukee, Wis., to Duluth, Minn., aboard the S/V *Denis Sullivan,* a re-creation of a 19th century three-masted Great Lakes schooner. Half of the educators were new to CGLL, and half had previously participated in a shipboard workshop (mentor teachers). The week-long workshop centered on mentor teachers sharing their experiences integrating Great Lakes science into their teaching. In addition, CGLL staff invited two graduate students to help facilitate the workshop. This presentation will highlight the successes, challenges and future directions of this pilot program. *Keywords: Environmental education, Professional development, Zooplankton, Shipwrecks.*

KLINARD, N.V.[1], COLBORNE, S.F.[1], JOHNSON, T.[2], HALFYARD, E.A.[3], CONROY, M.J.[4], CONNERTON, M.[5], and FISK, A.T.[1], [1]Great Lakes Institute for Environmental Research, 2601 Union Street, Windsor, ON, N9C 1A2, CANADA; [2]Ontario Ministry of Natural Resources and Forestry, 41 Hatchery Lane, Picton, ON, K0K 2T0, CANADA; [3]Nova Scotia Salmon Association, 152 Trinity Lane, Beaver Bank, NS, B4G 1C2, CANADA; [4]Warnell School of Forestry and Natural Resources - University of Georgia, 180 E Green Street, Athens, GA, 30602, USA; [5]New York State Department of Environmental Conservation, 541 E Broadway, Cape Vincent, NY, 13618-0292, USA. **Post-stocking Behaviour, Habitat Use, & Survival of Hatchery-Reared Bloated Using Acoustic Telemetry.**

Until the mid-1950s, a diverse group of deepwater ciscoes including bloater (*Coregonus hoyi*) were part of Lake Ontario's native fish community, but has been reduced to a single shallow-water species (*C. artedi*). Attempts to re-establish a population of deepwater ciscoes consist of stocking hatchery-reared bloater in Lake Ontario with a future goal of releasing 500,000 juveniles per year. To determine the post-stocking behaviour, habitat use and survival of hatchery-reared bloater, 70 yearlings were implanted with acoustic transmitters and released with the yearly stock into the east end of Lake Ontario in Nov. 2015, as part of a four year study that will include further tagging and environmental monitoring. On an array of 80 acoustic receivers deployed in the St. Lawrence Channel of Lake Ontario, 67 tagged bloater were detected following release but dispersed quickly with 8 of the fish being detected after 7 months, demonstrating survival. Estimates of survival will be presented using Bayesian mark recapture models of the telemetry data. Establishing a self-sustaining population of deepwater ciscoes will help restore fish native to Lake Ontario, thus increasing biodiversity, improving food web stability, and serving as a basis for reintroduction and management of other native species throughout the Great Lakes.

Keywords: Lake Ontario, Fish behavior, Acoustics.

KLUMP, J.V., WECKERLY, K., WAPLES, J.T., SZMANIA, D., and KLUMP, P.D., Great Lakes WATER Institute, 600 E. Greenfield Ave., Great Lakes WATER Institute, 600 E. Greenfield Ave., Milwaukee, WI, 53204, USA. **The potential biogeochemical Impact of impoundments in the Green Bay watershed.**

Reservoir-induced aging of continental runoff has been shown to be an anthropogenically induced global phenomenon with estimates that the mean age of river water reaching the coastal ocean has likely tripled historically. This has been hypothesized to have a significant biogeochemical impact on land-margin systems by altering flow regimes, net water balances and residence times, nutrient and carbon cycling, and sediment storage and transport. The Fox-Wolf watershed of Green Bay contains more than 20 reservoirs, impoundments and lakes on the main stems of the two principal rivers that feed Green Bay and Lake Michigan. These impoundments function as a series of linked biogeochemical reactors which process and repackage nutrients, retard flow, sequester material, and significantly attenuate the flux of materials into sequential down¬stream "pools". Variations in isotopic signatures, nutrient stoichiometry and composition may provide insights into biogeochemical cycling either at the level of the individual reservoir or at the level of the entire land-margin system, and into whether the residence time and aging within successive impoundments plays an important role in the biogeochemical structure of this ecosystem.

Keywords: Biogeochemistry, Reserviors, Green Bay, Watersheds.

KNACKSTEDT, K.[1], GLASGO, E.[1], MOFFETT, B.F.[2], HILL, T.C.J.[3], BULLERJAHN, G.S.[1], and MCKAY, R.M.L.[1], [1]Bowling Green State University, Bowling Green, OH, 43403, USA; [2]Ocean Lab, Fishguard Harbour, Goodwick, Pembrokeshire, SA64 0DE, WALES; [3]Colorado State University, Fort Collins, CO, 80523, USA. **Ice Nucleating Particles of Rivers and River Spray Aerosols.**

Ice nucleating particles (INPs) are a neglected, but integral component of the water cycle. Preliminary evidence is presented showing that rivers and lakes possess high numbers of warm temperature (≤ -10 °C) biological INP and that these may become airborne, especially in association with features promoting turbulence. Focusing our studies on the Maumee River, the largest tributary to Lake Erie, we present a seasonal analysis of surface water INP along with assessment of their potential to become aerosolized. Abundance of

warm temperature INPs from the surface microlayer spanned 3-orders of magnitude reaching a maximum of 50000/mL during their peak in early spring. This compares with values < 1 INP/mL in surface seawater. In air sampled from below a weir spanning the river, the number of warm temperature INP was around 0.02/L at -10 °C. Recognizing that some INPs are derived from bacteria, we conducted a seasonal microbial community profile, although, preliminary data indicate that the majority of the INP were subcellular. Combined with recent surveys of other major US rivers, there is growing consensus that the presence of abundant warm temperature INP is a common, if not ubiquitous, feature of fresh water systems. *Keywords: Maumee River, Microbiological studies, Ice.*

KNAPP, K.L., BIDDANDA, B.A., and WEINKE, A.D., Annis Water Resources Institute GVSU, Muskegon, MI, USA. **Time-space variable carbon cycling in Muskegon Lake using time-series data.**

Although lakes account for a small percentage of the Earth's surface area, they are emerging as hotspots in the global carbon cycle. Gross primary production (GPP) and respiration (R) are primary components of carbon metabolism and determine the net ecosystem production (NEP) and if a lake is a source or sink of carbon. Muskegon Lake is a drowned river mouth to the 2nd largest watershed in Michigan and serves as a model freshwater estuary as it exchanges water with Lake Michigan. Spatial and temporal variation in rates of carbon metabolism was investigated using *in situ* dissolved oxygen data from the Muskegon Lake Observatory (www.gvsu.edu/buoy) from 2011 - 2016. Based on previous studies, the spring, summer and fall months GPP was higher resulting in positive NEP, and during the winter R was slightly higher than GPP. Vertical rates of GPP and R are expected to decrease through the whole water column. Time-series data allows scientists to understand the variability of an ecosystem with higher frequency compared to manual sampling methods. These observatory-based findings can advance our understanding of how and why the cycling of carbon varies in lakes, and serve as a model for similar lakes and coastal waters around the world. *Keywords: Observing systems, Carbon cycle.*

KNAUFF, R. and HOFFMAN, M., Rochester Institute of Technology, Rochester, NY, 14618, USA. **Three-Dimensional Modeling of Plastic Transport in the Great Lakes.**

We model the input and three-dimensional transport of plastic particles in the Great Lakes. We assume that particle release into the Great Lakes is proportional to nearshore population and then input neutral density particles which are propagated around the Lakes using currents from NOAA's operational nowcasts. The nowcasts do not contain vertical velocity fields, so vertical velocities are first computed and then used in the transport model to advect the simulated particles. The predicted particle distributions are then compared to previously published samples for verification. In addition, the three-dimensional results are compared to particle distributions from previously published two-dimensional simulations to quantify the effect of vertical velocity on both the modeled distributions and the derived floating plastic mass estimates. *Keywords: Microplastics, Modeling, Pollutants.*

KNEISEL, A.N.[1], COOPER, M.J.[2], and UZARSKI, D.G.[1], [1]The Institute for Great Lakes Research, Central Michigan University, Mount Pleasant, MI, 48858, USA; [2]Mary Griggs Burke Center for Freshwater Innovation, Northland College, Ashland, WI, 54806, USA. **The Impact of *Phragmites australis* Invasion on Great Lakes Coastal Wetland Macroinvertebrates.**

The invasive strain of *Phragmites australis* is expanding its range in Great Lakes coastal wetlands and altering the habitat for wetland organisms. Aquatic macroinvertebrates are likely to be affected as community composition can depend on vegetation type. However, past studies have not definitively characterized the impact of invasion on invertebrates. We predicted that when compared to aquatic macroinvertebrate communities in native vegetation, communities from *P. australis* patches would be more dominated by common taxa, have a higher proportion of the shredder functional feeding group, and have lower richness. We sampled aquatic macroinvertebrates from the sediment and water column in patches of invasive *P. australis* and adjacent native wet meadow patches. The vegetation pairs were located in 5 sites on the coast of Thunder Bay in western Lake Huron and were sampled in 2015 and 2016. Additionally, in 2016, we sampled 3 sites with little *P. australis* in northern Lake Huron and 3 sites dominated by *P. australis* in Saginaw Bay. While richness did not differ between vegetation types, we observed a shift towards amphipods in the invaded communities. An increase in amphipods, which are omnivorous and opportunistic, could reflect the flexible traits needed by fauna to survive post invasion.
Keywords: Macroinvertebrates, Phragmites australis, Wetlands.

KNIGHT, J.C.[1], O'MALLEY, B.P.[2], and STOCKWELL, J.D.[2], [1]Eastern Michigan University, Ypsilanti, MI, 48197, USA; [2]University of Vermont, Burlington, VT, 05405, USA. **Benthic invertebrates along a depth gradient in Lake Champlain: 2016 vs 1991.**

Benthic invertebrates are an important bioindicator of water quality and play a significant role in aquatic systems. Lake Champlain, which has a maximum depth of 122 m, has very limited benthic invertebrate data which precludes development of food web models, assessment of invasive species impacts, and evaluation of management actions. We used a Ponar sampler to explore current diversity, density and biomass of invertebrates along three transects across sampling sites ranging from 5 to 100 m depth in the lake's main basin. Results were then compared to densities from a limited benthic invertebrate survey in 1991 prior to the zebra mussel (*Dreissena polymorpha*) invasion. We found diversity, density, and biomass of benthic invertebrates were consistent from 20 to 100 m depths compared to those at 5 m, which were significantly greater. Zebra mussels, gastropods, and chironomids had higher densities at 5 m compared to 20-100 m where oligochaetes, nematodes and sphaeriids dominated. However, we found total density at the nearshore depth (5 m) was 98% lower in 2016 compared to 1991. Our results can be used to better understand impacts of potential invasive species such as the quagga mussel (*D. bugenisis*) which has transformed the benthic communities of the Great Lakes. *Keywords: Benthos, Lake Champlain, Monitoring, Benthic invertebrate, Zebra mussels.*

KONOPKA, A.[1], JONES, T.[2], MESSERLY, E.[2], SALTZMA, B.[2], VALIGOSKY, M.[2], and AMES, A.[2], [1]Bowling State University, Bowling Green, OH, 43403, USA; [2]University of Toledo, 2801 W. Bancroft St., Toledo, OH, 43606, USA. **Using GIS to Characterize Recreational Water Use in the Western Basin of Lake Erie.**

Harmful algal blooms (HABs) are a worldwide issue and increasing in Lake Erie. HABs may affect recreational activities including boating, swimming, or fishing. Our purpose was to identify and characterize recreational users of Lake Erie including their behaviors, using Geographic Information Systems and a self-administered, quantitative survey. Outreach methods included: interviewers at points of interest, contact with water user groups, and at lakeside activities/events. Other targeted populations included a random selection of registered boaters, licensed anglers, and residents within 0.8 km of Lake Erie in Lucas, Ottawa, and Sandusky counties in Northwest Ohio. Preliminary results (n=309) suggest the top three recreational water-related activities were shoreline walking (73.8%), motorized boating (63.8%), and fishing (56.6%). The majority (53.7%) used the lake for over 25 years. Most water users are weekly users or participate once or twice per year. The three most important factors affecting Lake Erie use decisions were beach closings due to bacteria, algae, and beach cleanliness. A population of recreational users and their behaviors has been identified for future directions including 1) a pilot study quantifying airborne microcystin levels; and 2) examining symptoms reported by recreational users associated with HABs. *Keywords: Harmful algal blooms, Lake Erie, Economic impact.*

KOOPS, M.A., BOWEN, K.L., CURRIE, W.J.S., FITZPATRICK, M.A., NIBLOCK, H., and MUNAWAR, M., Fisheries and Oceans Canada, 867 Lakeshore Rd, Burlington, ON, L7S 1A1, CANADA. **Ecosystem Responses to Eutrophication and Nutrient Control: A View from the Bay of Quinte.**

The Bay of Quinte is a large embayment along the north shore of Lake Ontario which was listed as an Area of Concern (AOC) under the Great Lakes Water Quality

Agreement based on eutrophication issues. The Bay of Quinte experienced cultural eutrophication through the early and middle 20th century, followed by nutrient control strategies and studies to understand how these actions affected the ecosystem. These research and monitoring activities originated in 1972, and have now generated a 44 year time series of data that have been used to examine processes and responses in many parts of the ecosystem. Here we will provide an overview of the breadth of work conducted on the Bay of Quinte and what has been learned about its responses to nutrient control.
Keywords: Eutrophication, Bay of Quinte, Nutrients.

KORNIS, M.S., U.S. Fish and Wildlife Service, Green Bay Fish and Wildlife Conservation Office, 2661 Scott Tower Drive, New Franken, WI, 54229, USA. **History of round goby invasion and ecological effects in the Laurentian Great Lakes.**

The round goby (*Neogobius melanostomus*) is one of the most wide-ranging invasive fish on earth, with substantial introduced populations in North America and Europe. Round gobies were first detected in the Laurentian Great Lakes in 1990, and rapidly spread throughout all five lakes. Ballast water transfer was responsible for the introduction and initial spread of round goby, but the species has since expanded on its own along lake shorelines and into connected rivers. Several deleterious ecosystem effects are known, including alteration of invertebrate assemblages, habitat competition with native benthic fishes, consumption of eggs from several fish species, facilitation of bioaccumulation of contaminants, and transference of botulism to fish-eating birds. These effects appear diminished in tributaries, where round goby densities are usually low compared to the Great Lakes. Round gobies also serve an increasingly important role as forage for many piscivorous species, including several that support recreational or commercial fisheries. Research needs for fisheries management include improving methods for estimating round goby abundance, inclusion of round gobies in food web models, understanding the triggers and timing of seasonal migrations, and determining spatial and seasonal variability in inclusion in piscivore diets. *Keywords: Round goby, Fisheries, Invasive species, Management.*

KORNIS, M.S.[1], TRESKA, T.J.[1], HANSON, S.D.[1], HOLEY, M.E.[1], BREIDERT, B.[2], CLARAMUNT, R.M.[3], DONNER, K.[5], JONAS, J.L.[3], MADENJIAN, C.P.[4], LENART, S.[5], MARTEL JR., A.W.[6], MCKEE, P.C.[7], OLSEN, E.J.[8], ROBILLARD, S.R.[9], and BRONTE, C.R.[1], [1]U.S. Fish and Wildlife Service, 2661 Scott Tower Drive, New Franken, WI, 54229, USA; [2]Indiana Department of Natural Resources, 100 West Water St., Michigan City, IN, 46360, USA; [3]Michigan Department of Natural Resources, 96 Grant Street, Charlevoix, MI, 49720, USA; [4]U.S. Geological Survey, 1451 Green Road, Ann Arbor, MI, 48105, USA; [5]Little Traverse Bay Band of Odawa Indians, 7500 Odawa Circle, Harbor Springs, MI, 49770, USA; [6]Little River Band of Ottawa Indians, 2608 Government Center Dr., Manistee, MI, 49660, USA; [7]Wisconsin Department of Natural Resources, Sturgeon Bay, WI, 54235, USA; [8]Grand Traverse Band of Ottawa and Chippewa Indians, 2605 NW Bayshore Drive, Suttons Bay, MI, 49682, USA; [9]Illinois Department of Natural Resources, 9511 Harrison Street, Des Plaines, IL, 60016, USA. **Post-release survival of lake trout stocked at four historical spawning sites in Lake Michigan, USA.**

Since the 1950s, fisheries agencies have pursued rehabilitation of lake trout (*Salvelinus namaycush*) populations in Lake Michigan through stocking, sea lamprey control, and harvest regulations. We sought to identify factors related to post-release survival of coded-wire tagged (CWT) lake trout stocked in Lake Michigan at four historical spawning sites. We used data from long-term fishery-independent surveys to compare relative post-release survival of lake trout, estimated by catch per unit effort corrected for the number of fish stocked (CPUE), across 173 CWT tag lots of the 1994 - 2003 year classes. Boosted regression trees were used to assess the relative influence of six variables in explaining variance in lake trout CPUE. Stocking location (60.6%), genetic strain (13.2%), and total length at release (12.0%) were very influential while hatchery (6.2%), predator density (4.8%), and mortality at release (3.1%) had little influence. CPUE was lowest for fish stocked in the north, where there was a truncated age structure and higher rates of sea lamprey wounding. At the other three stocking locations, CPUE was higher from Lake Michigan remnant genetic strains and from fish with larger length at stocking. Our results have implications for wild lake trout reproduction and for future stocking strategy modifications. *Keywords: Lake trout, Fisheries, Management.*

KOSIARA, J.M., STUDENT, J.J., and UZARSKI, D.G., Central Michigan University, 1455 Calumet Ct, Mt Pleasant, MI, 48859, USA. **Exploring coastal habitat-use patterns of Great Lakes yellow perch with otolith microchemistry.**

Knowledge of the spatial ecology and movement of fishes is key for progressing resource management. Elemental analyses of otoliths has made it possible to unveil these movement patterns for fishes, like yellow perch, living in complex habitats of the Great Lakes. Yellow perch were collected from 26 wetland-nearshore site pairs throughout the Great Lakes basin in the summers of 2014 and 2015. Otoliths were thin sectioned and analyzed from core to edge for Ca, Mg, Mn, Sr, Ba, Zn, Cu, and Pb. Otolith edge chemistry was used to inform classification models which were applied across entire otolith transects to reconstruct habitat histories for each fish. For 5 of the sites, otolith edge chemistry did not differ between wetland and nearshore caught fish and classification was not possible. For remaining sites, classification accuracy ranged from 70-100% and habitat histories were constructed for 237 juvenile and adult yellow perch. Several patterns emerged ranging from

lifelong habitat residency, to regular, yearly movements between wetland and nearshore habitats. No one pattern appears to dominate, but approximately half of the perch analyzed moved between habitats at least once after formation of the first annulus. *Keywords: Yellow perch, Coastal ecosystems, Life history studies.*

KOVALENKO, K.E.[1], REAVIE, E.D.[1], BURLAKOVA, L.E.[2], KARATAYEV, A.Y.[2], RUDSTAM, L.G.[3], and BARBIERO, R.P.[4], [1]NRRI, University of Minnesota, Duluth, USA; [2]Great Lakes Center, Buffalo State College, Buffalo, USA; [3]Fisheries and Aquatic Science, Cornell University, Ithaca, USA; [4]CSRA, Chicago, USA. **Cross-lake comparisons of multi-assemblage breakpoints: the GLNPO story.**

Long time series data can provide interesting insights into dynamics of large lakes. We use the USEPA-GLNPO biological monitoring dataset (phytoplankton, benthos, zooplankton and water quality), collected from 1996 through 2014, to identify lake-specific breakpoints in major biotic and environmental parameters. Using breakpoint regression, we show abrupt and concurrent changes in biotic assemblages and water quality in some of the lakes, particularly Michigan and Huron. These include changes in phytoplankton community composition and biovolume, increasing Dreissena abundance and decreasing densities of other benthos. Biotic changes are accompanied by pronounced changes in nutrient ratios, indicating likely stoichiometric shifts affecting entire food webs. Species change-points, identified using threshold indicator taxon analysis, are often less abrupt, but there are clear shifts in key species in each assemblage. The concordance of breakpoints among assemblages or lack thereof provides valuable insight into potential drivers of ecosystem change. *Keywords: Zoobenthos, Phytoplankton, Dreissena.*

KOWALSKI, K.[1], MOORE, C.[3], BICKFORD, W.A.[1], DASILVA, A.[1], BRAUN, H.[2], FERRIER, E.[2], ALEXANDER, K.[2], and HAAK, D.[3], [1]United States Geological Survey, Ann Arbor, MI, USA; [2]Great Lakes Commission, Ann Arbor, MI, USA; [3]University of Georgia, Athens, GA, USA. **Developing the Phragmites Adaptive Management Framework (PAMF).**

Invasive Phragmites australis (Phragmites) affects more than 24,000 ha of the U.S. coastline, much of the Canadian coastline, and a significant amount of inland areas in the Great Lakes basin (GLB). Although managers invest substantial resources into managing invasive Phragmites, uncertainty about treatment effectiveness exists given variation in application approach, site-specific environmental conditions, and other factors. This presentation will focus on the status of an effort by the Great Lakes Phragmites Collaborative to develop an adaptive management framework that reduces these uncertainties through a collective learning process. The Phragmites Adaptive Management

Framework (PAMF) provides involved land managers with: annual treatment guidance generated by predictive models, an easy-to-use monitoring protocol that guides collection of key response data, and a database of information from each Phragmites patch enrolled in PAMF. While this framework is a tool to benefit land managers, PAMF also broadly benefits the GLB by: providing an opportunity to forward regional management through a structured framework, increasing transparency and accountability of resources invested, and uniting land managers, researchers and other stakeholders in a collaborative effort to manage Phragmites. *Keywords: Phragmites australis, Adaptive management, Great Lakes Restoration Initiative (GLRI), Regional analysis.*

KOWALSKI, K. and BICKFORD, W.A., U.S. Geological Survey Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105, USA. **A science agenda for managing non-native *Phragmites australis* through microbial intervention.**

Management of non-native *Phragmites australis* (common reed) is a high priority for resource managers. Conventional management strategies are not sustainable at the landscape scale, so innovative approaches are being developed. Using principles of the collective impact model, an international group of scientists formed the Collaborative for Microbial Symbiosis and *Phragmites* Management (PSC) in 2013. This group sought to establish the current state of the science and develop a research agenda to guide research on new microbial symbiosis-based control approaches. *Phragmites* harbors rich microbial communities comprised of both mutualists and pathogens. However, the specific roles and functions of most of these *Phragmites*-associated microbes have not been evaluated. Similarly, the steps needed to develop a management strategy based on symbiotic microbial relationships are unclear. The PSC published a recent paper highlighting a proposed science agenda that outlines four sequential steps and several tasks to guide the development of a microbe-based control strategy for *Phragmites*. These steps target the microbial relationships influencing the competitive abilities of invasive *Phragmites* and describe principles and approaches useful for microbiome manipulations in other invasive species.
Keywords: Microbiological studies, Phragmites australis, Invasive species.

KOZEL, C.L.[1], RINCHARD, J.[2], EVANS, A.N.[3], and MARSDEN, J.E.[1], [1]University of Vermont, 3 College St, Burlington, VT, 05401, USA; [2]State University of New York-The College at Brockport, 350 New Campus Drive, Brockport, NY, 14420, USA; [3]Oregon State University, Nash Hall, Room 104, Corvallis, OR, 97331, USA. **Early Feeding in Lake Trout Fry as a Mechanism to Ameliorate Thiamine Deficiency.**

Recruitment failure of lake trout (Salvelinus namaycush) in the Great Lakes has been attributed in part to the consumption of alewife (Alosa pseudoharengus) by adult lake trout, leading to Thiamine Deficiency Complex (TDC) and early mortality in fry. Current understanding of TDC in lake trout fry is based on information from hatchery settings, which do not represent conditions fry experience in the wild and may influence the occurrence of TDC. Hatchery-reared fry are not provided food until after yolk-sac absorption, after TDC has already manifested. However, wild lake trout fry have access to natural prey immediately following hatching; zooplankton are a potential source of dietary thiamine not previously considered in the occurrence of TDC. We postulated wild fry could mitigate a thiamine deficiency through feeding on natural prey. Eggs were collected from Lake Champlain in 2014 and Cayuga Lake in 2015; a fully crossed experimental design was used to determine the effect of feeding thiamine replete and thiamine deplete fry before and after feeding. Thiamine concentrations and survival did not significantly differ between fed and unfed fry. Thiamine concentrations increased from egg stage to hatching in both years, suggesting a potential source of thiamine was available to the lake trout eggs during development. *Keywords: Thiaminase, Vitamin B, Lake trout.*

KRABBENHOFT, C.A. and KASHIAN, D.R., Wayne State University, 5047 Gullen Mall, Detroit, MI, 48202, USA. **Native community dynamics and round goby invasion in Great Lakes tributaries.**

Many factors may influence the ability of a nonnative species to successfully colonize a new area. We tested the hypothesis that round goby (*Neogobius melanostomus*) invasion is associated with decreased diversity of native benthic competitors. Surveys were conducted at three sites in each of five Michigan tributaries to the Great Lakes over two years. At each site, we assessed community composition and diversity of fishes. Fish diversity was normalized across the landscape and compared to round goby abundance. Although community composition varied for each sample, fish diversity did not change at the site or watershed level over time. Species aggregation was observed at site and watershed levels indicating potential interaction with habitat availability. Native benthic species most likely to compete with round goby (e.g., darters) were lower in abundance ($p=0.005$) where round goby were most abundant. Similarly, round goby abundance was greater ($p=0.020$) at sites with lower diversity in 2015 but not 2016. This inconsistency potentially suggests additional environmental factors (such as habitat availability, contaminants, food resources, etc.) may also be important drivers. With further analysis, we hope to identify causal factors constraining or promoting goby invasion and determine their impact on newly invaded areas. *Keywords: Biodiversity, Tributaries, Round goby.*

KRABBENHOFT, D.P.[1], JANSSEN, S.E.[1], LEPAK, R.L.[2], HOFFMAN, J.C.[3], MONSON, B.[4], OGOREK, J.M.[1], DEWILD, J.F.[1], and TATE, M.T.[1], [1]U.S. Geological Survey, 8505

Research Way, Middleton, WI, 53562, USA; [2]Environmental Chemistry and Technology Program, University of Wisconsin-Madison, Madison, WI, 53706, USA; [3]USEPA, National Health and Environmental Effects Research L, Duluth, MN, 55804, USA; [4]4Minnesota Pollution Control Agency, St. Paul, MN, MN, 55155, USA. **Determination of MeHg Sources to Fish in the St. Louis River, MN, USA, using Hg Stable Isotopes.**

Mercury (Hg) contamination in the Great Lakes region is a concern due to elevated methylmercury (MeHg) levels in fish. While atmospheric deposition of Hg is ubiquitous across the region and is the primary Hg source for fish from the open waters of the Great Lakes, there also exist several point-source affected locations (known as Areas of Concern - AOCs), which are the result of legacy contamination and exhibit substantially elevated Hg contamination levels. One of these AOCs is the lower St. Louis River (SLR) estuary, which has MeHg concentrations in predatory fish about twice that of Lake Superior. The aim of this study is to utilize Hg stable isotopes to elucidate sources of MeHg to fish in the SLR estuary. Overall, these results suggest SLR estuary walleye and white suckers bioaccumulated Hg from the estuary sediments. However, further study is needed to distinguish among the two primary sources of Hg to the SLR estuary sediments: legacy and watershed inputs. In order to fully address the sources of MeHg to the St. Louis food web, further experiments examining the isotopic composition of MeHg pools in sediments and fish tissue will be performed. *Keywords: Mercury, Source identification, Methylation, St. Louis River AOC.*

KRABBENHOFT, T.J. and DOWLING, T.E., Wayne State University, 5047 Gullen Mall, Dept Biological Sciences, Detroit, MI, 48202, USA. **Population Genomics of Invasive Sea Lamprey (Petromyzon marinus) in the Laurentian Great Lakes.**

Sea lamprey (Petromyzon marinus) is an invasive species in the Laurentian Great Lakes, where they have caused significant damage to fisheries. An important question is whether sea lamprey is adapting to local Great Lakes conditions. Additionally, knowledge of streams acting as sources of sea lamprey is needed to maximize effectiveness of targeted control efforts. We used RAD-seq to assess the genetic distinctiveness of larval sea lampreys collected in tributaries across the Great Lakes basin. We used SNP data to test the following hypotheses: (1) sea lampreys are genetically homogeneous among streams; (2) a few SNPs will exhibit signatures of adaptation to local stream conditions (3) high Fst SNPs can be used to diagnose stream-of-origin of lamprey collected in open lake habitats. Differentiation among localities was generally low for most SNPs ($Fst<0.05$); however, a few outlier SNPs exhibited significant differentiation among streams. Two of the outlier loci were located in genes possibly associated with lampricide metabolism and may reflect differences in lampricide treatment history among streams. These data illustrate that high levels of gene flow impact the majority of the genome; however, some loci may be locally adapted, including some that are candidates for future studies of potential lampricide resistance. *Keywords: Fisheries, Genomics, Genetics, Fish, Invasive species.*

KRABBENHOFT, T.J.[1], STOTT, W.[2], YULE, D.L.[3], and DOWLING, T.E.[1], [1]Wayne State University, Detroit, MI, USA; [2]Michigan State University, East Lansing, MI, USA; [3]Lake Superior Biological Station, Ashland, WI, USA. **Transcriptomics identifies genes associated with functional differences among Great Lakes ciscoes.**

We sequenced expressed genes (e.g., transcriptome) from the heads of eight individuals from each of the four species of ciscoes found in Lake Superior (*Coregonus artedi*, *C. hoyi*, *C. kiyi*, and *C. zenithicus*). This approach identified sequence polymorphisms (SNPs) within or in the flanking regions of many expressed genes. A portion of these SNPs were taxonomically-informative and comparison of these genes with the annotated genome sequence of zebrafish indicated that many of these genes are associated with lipid metabolism (associated with depth preferences) and head shape development (associated with trophic morphology). These results require further validation, which would be provided by increasing sample sizes for each of the species. *Keywords: Fish management, Genetics, Species diversity.*

KRAMER, E.L. and BRIDGEMAN, T.B., University of Toledo, 2801 W. Bancroft St., Toledo, OH, 43606-3390, USA. **Avoiding HABs at Toledo's Drinking Water Intake by Observing Vertical Distribution and Migration.**

The increasing severity of Harmful Algal Blooms (HABs) in the Western Basin of Lake Erie necessitates investigation into new methods for protecting vital drinking water sources. The dominant HAB species in Western Lake Erie, *Microcystis aeruginosa*, has been shown to change its position in the water column according to time of day and wind mixing. The city of Toledo drinking water intake is located at mid-depth in the lake, therefore it may be possible to reduce intake exposure to *Microcystis* by increasing pumping rates when *Microcystis* is concentrated either at the lake surface or at the bottom. This would lower the concentrations of algal toxins that enter a water plant, protecting important drinking water resources and reducing treatment costs. In August 2016, two 24-hour sampling events were conducted to observe the vertical distribution of HABs and other algal species. The results of these studies are presented, and additional sampling events are planned for 2017. *Keywords: Harmful algal blooms, Drinking water, Lake Erie.*

KRANTZBERG, G., McMaster University, 1280 main st. w, hamilton, on, l8s4k1, CANADA. **Assessing governance capacity for nearshore zones and AoCs.**

The creation of remedial action plans for the Great Lakes Areas of concern were an experiment in addressing anthropogenic stress on human and nonhuman uses of the nearshore zones. This talk examines the governance assets and deficits that can benefit from an adaptive governance approaches. More specifically, it proposes a framework for assessing adaptive capacity and tests this framework in the case where adaptive capacity was displayed. This research also aims to identify gaps in adaptive capacity for current governance arrangements in the ongoing effort to regenerate excellence in the Areas of Concern, with a view forward to nearshore governance frameworks under both Annex 1 and Annex 2 of the Great Lakes Water Quality Agreement protocol of 2012. *Keywords: Environmental policy, Impared water use, Management.*

KRAUSFELDT, L.E.[1], BOYER, G.L.[2], and WILHELM, S.W.[1], [1]Department of Microbiology, University of Tennessee, Knoxville, TN, 37996, USA; [2]College of Environmental Science and Forestry, State University of New York, Syracuse, NY, 13210, USA. **The <'>mlr pathway for microcystin degradation may not be relevant in Lake Erie and Lake Tai.**

Microcystin (MC) is a potent hepatotoxin produced by several bloom-forming cyanobacteria. MC is thought to remain intracellular until it is released during cell lysis, and microbial degradation has been suggested to be the most important route for the disappearance of MC in the environment. The only known pathway for this process is the well-characterized mlrABCD pathway: it is most extensively studied in laboratory settings using putative MC-degrading isolates. Few studies, however, have quantified these genes in environmental samples. To assess the activity of this pathway in the environment, available metatranscriptomes from two important freshwater systems, Lake Erie and *Taihu*, were screened for the expression of the *mlr* pathway. Phylogenetic analyses of assembled reads for the marker gene, *mlrA*, suggested that *mlrA* was not being expressed during toxic blooms. Consistent with these results, only 157 of 3.5 billion reads mapped to the *mlr* operon, despite over 3 million reads mapping to the *mcy* (microcystin production) operon. Our observations suggest that despite the production of significant MC at the time of sampling, the *mlr* pathway was not active supporting the on-going hypothesis that another pathway is involved in microbial degradation of MC in Lakes Erie and Tai. *Keywords: Harmful algal blooms, Metatranscriptomics, Microcystin degradation.*

KRIEGER, J.R.[1], YOUNG, R.T.[2], and DIANA, J.S.[1], [1]School of Natural Resources and Environment/ University of Michigan, 440 Church St., Ann Arbor, MI, 48109, USA; [2]USGS Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105, USA. **Development**

and Evaluation of A Habitat Suitability Models for Young Lake Sturgeon in the GLCCs.

We expanded on a previous study to evaluate the quantity, quality, and spatial distribution of riverine nursery habitat for larval, YOY and juvenile (<500mm) lake sturgeon (*Acipenser fulvescens*) in the North (NC) and Middle Channel (MC) of the St. Clair River and the Fighting Island Channel (FIC) of the Detroit River (DR), using habitat suitability modeling (HSM) and fish collections. These HSMs were developed using local, georeferenced habitat information on substrate, invertebrate densities, benthic flow, and water depth. Model outputs indicated a significantly higher abundance of high quality habitat present in NC (29.1%) when compared to both the MC and the FIC (15.1% and 16.8%, respectfully), with subsequent variation in larval lake sturgeon dispersal patterns. In the NC, larva appeared to concentrate in areas of preferred habitat, where YOY and juvenile individuals were also found. In the MC, larvae also appeared to concentrate in distinct locations but spatial distribution appeared more uniform throughout the channel. In the FIC, larva appear to exit the channel into the DR, with some evidence that juveniles may return later in life. These patterns suggest a level of variability in young lake sturgeon ecology for populations in the GLCCs with variations dependent on local habitat conditions.
Keywords: Life history studies, Lake sturgeon, Fish management, Modeling.

KRISHNAN, A. and MOU, X., Kent State University, 1781 E Summit Street, Kent, OH, 44240, USA. **Identification of a novel microbial degradation pathway for microcystins.**

Excessive nutrient loading in the form of industrial waste and fertilizer run off has led to the formation of harmful cyanobacterial blooms (CyanoHABs) in Lake Erie. These CyanoHABs produce a number of cyanotoxins, predominantly, a class of liver toxins called microcystins (MCs). MCs share a cyclic structure that possesses integrity under a wide range of temperature and pH. In natural environments, MCs are removed through microbial activities. A bacterial MC-degrading pathway encoded by *mlr* genes has been previously identified. However, recent metagenomics study has indicated an alternative pathway for MC degradation in MC+ bacteria from Lake Erie. The aim of this study was to prove and identify this novel pathway. Of the 40 MC+ bacteria we isolated from Lake Erie, LE_24 (affiliated with *Pseudomonas aeruginosa* based on 16S rRNA genes) showed the highest MC degradation rate and *mlr* gene absence. The given isolate was mutated with Tn5 and a gene knockout library was created. The library was screened for non MC degrading (MC-) mutants which were cleaved using HindIII and XhoI. Of the mutants obtained and screened, 6 were MC-. These 6 mutants were treated with XhoI and HindIII and the region sequenced. The future direction for this project would be identification of the degradation products using LC-MS. *Keywords: Harmful algal blooms, Microcystis, Lake Erie.*

KRUG, M.[1], BROCKMAN, J.[1], CZARNECKI, A.[1], GILOT, G.[1], HAMLET, A.F.[1], NELL, R.[2], WOOD, D.[1], and ZORNIG GURA, A.[1], [1]University of Notre Dame, Notre Dame, IN, 46556, USA; [2]enFocus Inc., 506 W South St., South Bend, IN, 46601, USA. **Green Infrastructure and Community Revitalization: Opportunities in the Bowman Creek Watershed.**

Green infrastructure is increasingly seen as a viable method of stormwater management, but successful implementation requires an understanding of the social context of the area. Many barriers for implementation are impacted by sociocultural factors of the community, such as residents' willingness to adopt green stormwater infrastructure and contribute to ongoing maintenance. Cities must incorporate an integrated planning approach to implementation which combines community perspectives and understands the social context of the area. This case study analyzes one example in the area around Bowman Creek, an impaired creek in South Bend, IN draining to the St. Joseph River watershed. The Bowman Creek Educational Ecosystem was instrumental in connecting neighborhood associations, residents, university researchers, students, local businesses, and city government officials to reimagine how environmental and social issues are intertwined in the neighborhood surrounding the creek. Analyzing the challenges and lessons learned from this organization informs an evolving strategy for addressing key questions in this sphere, including opportunities for community engagement with green infrastructure, communication of social benefits of green infrastructure, and project development to meet technical and social needs of different stakeholders. *Keywords: Public participation, Green infrastructure.*

KUCZYNSKI, A.[1], AUER, M.T.[1], and CHAPRA, S.C.[2], [1]Michigan Technological University and Great Lakes Research Center, 1400 Townsend Dr., Houghton, MI, 49931, USA; [2]Tufts University, 419 Boston Ave, Medford, MA, 02155, USA. **Development, Calibration, and Confirmation of the Great Lakes *Cladophora* Model v3.**

Nuisance growth of the filamentous green alga *Cladophora* results in beach fouling, clogged water intakes, and other negative effects. The Great Lakes *Cladophora* Model v1 (GLCM) is a mechanistic model first published in 1982. Its successors are the *Cladophora* Growth Model (2005) and the Great Lakes *Cladophora* Model v2 (2010). The models simulate *Cladophora* biomass density and stored phosphorus (Q) with respect to light, temperature, and nutrient levels. This work improves several algorithms in the existing models to create the GLCM v3. Light and temperature response surfaces are refitted to original

measurements. Limitation of growth by Q is redefined based on measurements of the net specific rate of photosynthesis with respect to Q. Measurements of the phosphorus uptake rate were made to improve its relationship with respect to Q and external soluble reactive phosphorus concentration. Sloughing is redefined based on field measurements of bottom currents; we derive a function for current velocity at depth based on wind speed. The calibrated and confirmed GLCM v3 is an improved version of existing *Cladophora* models that will serve to set a phosphorus standard, a Substance Objective as per the Great Lakes Water Quality Agreement of 2012, for *Cladophora* management in the Great Lakes.
Keywords: Cladophora, Modeling, Phosphorus.

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LABUHN, K.A.[1], CALAPPI, T.J.[1], GRONEWOLD, A.D.[2], ANDERSON, E.J.[2], and KOWALSKI, P.J.[3], [1]U.S. Army Corps of Engineers, 477 Michigan Avenue, Detroit, MI, 48226, USA; [2]Great Lakes Environmental Research Laboratory, 4840 South State Road, Ann Arbor, MI, 4810, USA; [3]Ontario Power Generation, 14000 Niagara Parkway, niagara-on-the-Lake, ON, LOS1J0, CANADA. **Optimizing Water Levels in the Grass Island Pool for Hydropower Production on the Niagara River.**

Hydropower on the Niagara River can produce 4.9 million kilowatts of electricity. Short-term water level fluctuations on Lake Erie can affect the amount of water available for hydroelectric generation in the Chippewa-Grass Island Pool (CGIP) where the power entities have intakes. Given enough lead time, the Niagara River Control Center can more effectively manage water levels to optimize electrical production within the strict constraints of the 1950 Niagara River Treaty. Three federal partners developed a new tool for the Niagara River Control Center to help with this optimization. The Great Lakes Environmental Research Laboratory, National Weather Service and the U.S. Army Corps of Engineers developed and operationalized a set of tools necessary to forecast wind-induced water level changes on Lake Erie and estimate the lag-time to the CGIP. The forecast tools project levels at the head of the Niagara River for the coming 120 hours. The results are supplied to a one-dimensional model of the Niagara River. The result of this modeling will provide the Niagara River Control Center an estimate of water in the CGIP and allow for optimal dispatch of water to the power entities. *Keywords: Decision making, Flow Forecasting.*

LAJAVIC, J.M.[1], BRIGGS, A.S.[1], BOWEN, A.K.[2], and BOASE, J.C.[1], [1]U.S. Fish and Wildlife Service Alpena FWCO - Waterford Substation, Waterford, MI, USA; [2]U.S. Fish and

Wildlife Service Alpena FWCO, Alpena, MI, USA. **Using Social Media from a Field Office Perspective to Engage the Public with Fisheries Science.**

In today's society, social media is a valuable tool for increasing the awareness of conservation science through rapid exchange of information. It has had an important impact on fisheries science by connecting the public with fisheries management issues. The Alpena Fish and Wildlife Conservation Office's (FWCO) Facebook Page is unique from other similar pages in that it often showcases day to day activities and updates rather than highlighting specific results or published research. Using Facebook from a field office perspective is effective in increasing awareness of Great Lakes fisheries science and outreach efforts. This Facebook page also allows the public the opportunity to directly interact with the agency. The Alpena FWCO's Waterford Substation is moving to the Detroit River International Wildlife Refuge this year. With this change, it's expected that the Facebook page will expand with more followers and a greater reach to the public. *Keywords: Education, Social Media, Outreach, Communication, Public education.*

LAJOIE, C., LOVE, O.P., and PITCHER, T.E., Great Lakes Institute for Environmental Research, 401 Sunset Ave, Windsor, ON, N9B 3P4, CANADA. **Differential allocation of lipids and carotenoids in male and female spawning Chinook salmon.**

Semelparous Pacific salmon, such as Chinook salmon *(Oncorhynchus tshawytscha)* undergo drastic physiological and morphological changes during migration to reach their natal streams for reproduction. They cease feeding and rely on stored energy reserves to fuel migration and to aid in the development of secondary sexual characteristics. Rapid deterioration of an organism's soma as well as the irreversible harm that occurs due to extreme investment in reproduction is known as rapid senescence. We aimed to document the relationship between secondary sexual characteristics and differences in allocation patterns that exist between male and female chinook salmon. Both sexes were separated into two groups, those that do not show external degradation of the flesh (early senescence) and those that do (late senescence). We measured differences in lipid content (in muscle, gonads and eggs), carotenoid content (in muscle, eggs and sperm), and differences in morphometric traits (secondary traits) in both groups. Understanding how carotenoids and lipids are allocated during rapid senescence associated with spawning and how their levels may vary between early and late senescent individuals will lead to insight on the cost of reproduction for a semelparous species. *Keywords: Credit River, Senescence, Salmon, Reproduction Cost.*

LANGEN, V.L., Lakehead University, 955 Oliver Rd., Thunder Bay, ON, P7B 5E1, CANADA. **The effects of invasive dreissenid mussels on the offshore foodwebs of Lake Simcoe, Ontario.**

Zebra mussels (*Dreissena polymorpha*) are a species of great concern due to their ability to invade water bodies and cause ecological changes that can alter the structure and function of an ecosystem. Although much has been learned about the effects of these mussels on lake ecosystems, there is still some uncertainty regarding what changes seen in offshore foodwebs can be attributed to their establishment. This study evaluates the long-term changes in resource use of offshore fish in Lake Simcoe, Ontario and will determine the degree to which these changes can be associated with dreissenid mussel invasion. After analyzing stable isotope signatures of carbon ($\delta^{13}C$) from scales of coldwater fish species for the years 1960 - 2008, no obvious trends in C isotopes for offshore fish were found. However, the analysis of nitrogen isotopes ($\delta^{15}N$) indicated an increase over time. In addition, analysis for both of these isotopes will be conducted for the years 2009-2014. This is a time period that encompasses the more recent establishment of another invasive species, the Quagga mussel (*Dreissena rostriformis bugensis*). The results of this research will provide insight into how offshore fisheries may be altered after dreissenid invasion, and what influence Quagga mussels might have on the ecosystem. *Keywords: Fisheries, Foodweb, Lake Simcoe, Offshore, Dreissena, Energy flow.*

LAROCQUE, S.M.[1], JOHNSON, T.[2], WILSON, C.C.[3], SLOAN, B.[3], HEATON, M.[4], and FISK, A.T.[1], [1]Great Lakes Institute for Environmental Research - University of Windsor, Windsor, ON, CANADA; [2]Ontario Ministry of Natural Resources and Forestry, Picton, ON, CANADA; [3]Ontario Ministry of Natural Resources and Forestry, Peterborough, ON, CANADA; [4]Ontario Ministry of Natural Resources and Forestry, Aurora District, ON, CANADA. **Understanding movement of adult stocked Atlantic Salmon in a Lake Ontario tributary.**

In recent years, there have been efforts in restoring extirpated Atlantic Salmon (*Salmo salar*) back into Lake Ontario. With all the stocking activities of fingerlings or yearlings, there is a disproportionate amount of adult Atlantic Salmon returning to "natal" streams with little to no spawning activity observed. Spawning locations and movements post-spawning and overwintering of adult Atlantic Salmon within rivers of Lake Ontario is poorly understood. Using acoustic telemetry, hatchery-raised brood stock and returning Atlantic Salmon were tagged and monitored in the Credit River, Ontario, from Fall 2016 to Spring 2017, covering a distance of ~60 river kms and into Lake Ontario. Brood stock fish moved downstream post-release into the Credit River with little indication of spawning. One fish moved downstream into Lake Ontario within 10 days of being released - a 50 km journey. Whereas returning salmon had mixed upstream and downstream movements post-tagging release. This is our first look at behaviour/movement of stocked potamodromous Atlantic Salmon in fall and overwinter in an effort to better understand the challenges to poor adult returns and ultimately their restoration in Lake Ontario. *Keywords: Acoustics, Atlantic Salmon, Credit River, Migrations.*

LARSON, D.L.[1], HEGNA, J.R.[1], BAKER, E.A.[2], and SCRIBNER, K.T.[1], [1]Michigan State University, 2E Natural Resources Building 480 Wilson Road, East Lansing, MI, 48824, USA; [2]Michigan Department of Natural Resources, Marquette Fisheries Research Station 488 Cherry Creek Road, Marquette, MI, 49855, USA. **Factors Affecting Lake Sturgeon (Acipenser fulvescens) Spawning Migration in the Black River, MI.**

Variation in timing of spawning migrations for lake sturgeon(Acipenser fulvescens)and duration of occupancy of spawning areas are often attributed to environmental cues (e.g., temperature, discharge, day length) or biotic factors (e.g., operational sex ratios). Using PIT antenna arrays, data was collected from 341 lake sturgeon adults during the 2016 spawning season in the Black River, MI. Data on body size was obtained for a subset of adults upon capture on the spawning grounds. Timing of migration was most often observed between 20:00 and 10:00. Migration timing did not differ between sexes. Multiple intra-seasonal migration events were undertaken by individual males and females, contrary to previous reports. Based on Akaike's Information Criterion, models that included the largest lag change in water temperature over a 72-hour period prior to detection at the upstream spawning sites was the best predictor of daily number of migrating of lake sturgeon. Including the effect of discharge within a 24-hour lag improved model fit. Results show that lagged effects including increasing temperature and declining discharge strongly impact spawning behavior. Results of duration of migration, occupancy of spawning areas, and evaluation of the consequences of variation in migratory behavior to reproductive success will be discussed *Keywords: Migrations, Lake sturgeon, Fish behavior.*

LARSON, W.A.[1], STOTT, W.[2], TURNQUIST, K.N.[3], and SASS, G.G.[4], [1]U.S. Geological Survey, Wisconsin Cooperative Fishery Research Unit, 800 Reserve St., Stevens Point, WI, 54481, USA; [2]U.S. Geological Survey, Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105, USA; [3]Wisconsin Cooperative Fishery Research Unit, 800 Reserve St., Stevens Point, WI, 54481, USA; [4]Wisconsin Department of Natural Resources, 3110 Trout Lake Station Drive, Boulder Junction, WI, 54512, USA. **Developing a Rapture panel to investigate genetic diversity in cisco across the Great Lakes region.**

Cisco are native to the Great Lakes region and represent an important component of the food web as well as a valuable resource for commercial fishers. Abundance of cisco has declined significantly over the last century, prompting significant efforts to restore and conserve these species. The long term goal of our research is to inform conservation of cisco by improving our understanding of neutral and adaptive genetic variation. In this talk, we will focus on recent efforts to develop a panel of genetic markers for cisco using RAD capture (Rapture). Rapture combines two well established protocols, RAD and sequence capture, and facilitates efficient genotyping of 1000s of SNPs in hundreds to thousands of individuals. To construct the panel, we RAD sequenced 2-5 individuals from 20 inland populations throughout the Midwest and combined these data with data from Great Lakes cisco. Capture baits were then designed for SNP sequences identified from these data. We show results from phylogenetic analyses incorporating ascertainment individuals, discuss the panel development process, and outline how the Rapture panel will be used to address future research goals for cisco in the Great Lakes region. *Keywords: Genetics, Genomics, Fisheries, Coregonids, Conservation, Adaptation.*

LAURICH, B.[1], DRAKE, C.[2], and HEBERT, C.[3], [1]Calreton University, Colonel By Dr, Ottawa, On, K1A 0H3, CANADA; [2]Parks Canada Agency, Pukaskwa Rd, Unorganized Thunder Bay District, On, P0T 1R0, CANADA; [3]Environment and Climate Change Canada, Colonel By Dr, Ottawa, On, K1S5B6, CANADA. **Using stable isotopes and fatty acids to understand gull population declines on Lake Superior.**

In Pukaskwa National Park on Lake Superior, Herring Gull (*Larus argentatus*) population size is used as an indicator of ecological integrity. However, populations have declined by 80% since the 1970s. One factor that may be regulating these declines is food availability. Lake-wide declines in surface-schooling prey fish may be limiting natural food sources for Pukaskwa gulls. Birds in the southern section of the park have little to no access to human sources of food. In the northern section of the park, impacts of natural food declines may be buffered as birds can obtain anthropogenic food from nearby dumps. To assess regional differences in gull diets, Herring Gull eggs were collected from northern and southern parts of Pukaskwa National Park. Markers of diet composition, i.e. stable isotopes of nitrogen and carbon; fatty acids, were measured in the eggs. These analyses support the hypothesis that gulls from the southern end of the park rely to a greater extent on natural foods. The lack of alternative foods in the south may be contributing to more extreme population declines in that region. Understanding the degree to which anthropogenic food subsidies support Herring Gull populations is critical when utilizing gulls as an indicator of ecological integrity in Pukaskwa National Park. *Keywords: Avian ecology, Populations, Stable isotopes, Lake Superior.*

LAWRENCE, P.L., University of Toledo, 2801 W. Bancroft Street, Toledo, OH, 43606, USA. **What is in a Name? Should the Maumee AOC be the Toledo AOC?**

The Maumee Area of Concern is located in NW Ohio and was established in 1987,and even with several boundary revisions over the years this AOC has remained the largest in the United States at 787 square miles - in fact the Maumee AOC can hold 21 of the 26 US AOCs within its boundaries! The Maumee AOC covers six individual 10 digit HUCs representing 11 unique watersheds draining into the western basin of Lake Erie. Throughout the efforts and successes over the last 30 years with addressing the 10 beneficial use impairments identified for the Maumee AOC, rarely has the scale and size of the AOC been raised a potential barrier to progress and movement towards delisting. In addition, there is often confusion and misunderstanding among professionals and the public who assume with the name Maumee that this AOC addresses the wide and complex issues associated with the Maumee watershed, especially nutrient loading and the associated Lake Erie HABs, when in fact the Maumee AOC only represents 3.4% of the approximate 6,700 sq.miles of the Maumee watershed. The question and debate should be raised as to whether the name and associated size of the Maumee AOC is in fact presenting a limitation to further water quality and associated BUI improvements and creating a challenge of scope and scale when considering activities and priorities. *Keywords: Public education, Watersheds, Environmental policy.*

LEAHY, A.[1], FUTIA, M.[1], GORSKY, D.[2], JONAS, J.L.[3], and RINCHARD, J.[1], [1]The College at Brockport - State University of New York, 350 New Campus Drive, Brockport, NY, 14420, USA; [2]U.S. Fish and Wildlife Service - Lower Great Lakes Fish and Wildlife Conservation Office, 1101 Casey Road, Basom, NY, 14013, USA; [3]Michigan Department of Natural Resources - Charlevoix Fisheries Research Station, 96 Grant Street, Charlevoix, MI, 49720, USA. **Spatial comparison of Cisco fatty acid signatures between Lakes Michigan and Ontario.**

Cisco (*Coregonus artedi*) restoration is a major goal in Lakes Michigan and Ontario. Currently, Cisco populations are naturally expanding in Lake Michigan while intensive stocking efforts are being conducted in Lake Ontario. However, information regarding the biology of this species is limited and appears to vary. Information regarding Cisco diet is limited to stomach content analyses, which show differences in prey species between Lakes Michigan and Ontario (piscivorous and planktivorous, respectively), as well as variations within each lake. In the current study, Cisco were collected from Lake Michigan (n = 21; total length 479 ± 60 mm) and Lake Ontario (n = 45; total length = 297 ± 16 mm) during 2016. Lipids and fatty acids were extracted and fatty acid signature (FAS) will be compared to determine dietary variations within and between the lakes. Fatty acids are conservatively transferred from prey to predator and, therefore, can be used to determine diet and identify differences in foraging behaviors. In addition, we will evaluate lipid content and condition factor of Cisco from both systems to compare fish health status. Lastly, Cisco FAS will be compared to available FAS of other prey species from each lake to identify potential competition. *Keywords: Fatty acids, Cisco.*

LEE, D.H., NOAA Great Lakes Environmental Research Laboratory, 4840 South State Road, Ann Arbor, MI, 48108, USA. **The application of hydroclimate science to Lake Ontario-St. Lawrence River System regulation.**

On December 8th, 2016 a new regulation plan for the Lake Ontario-St. Lawrence River System was approved by both the U.S. and Canadian governments. The plan is the result of 16 years of scientific studies and engineering design, more than $20 million of investment, and extensive public engagement and stakeholder negotiation. Hydro-climate data were used extensively in the development and testing of the plan, including more than 100 years of historic water supplies, nearly 50,000 years of stochastic water supplies, and alternative climate change scenarios. The plan is unique in that it uses long-term and short-term forecasts of Lake Ontario total water supplies and short-term forecasts of Ottawa River and local tributary flows and ice roughness. Unlike its predecessor, the plan adjusts the rule curves for persistent wet or dry conditions and can be adapted to a changing climate. The development and application of the regulation algorithms using the hydro-climate data and forecasts are presented. *Keywords: Lake Ontario, Water management, St. Lawrence River, Hydroclimate applications, Environmental policy, Plan 2014.*

LEE, S.[1], JIANG, X.[2], MANUBOLU, M.[2], LUDSIN, S.A.[4], MARTIN, J.F.[5], and LEE, J.[1], [1]Environmental Science Graduate Program, Columbus, USA; [2]Department of Food Science and Technology, Columbus, USA; [3]College of Public Health, Division of Environmental Health Sciences, Columbus, USA; [4]Department of Evolution, Ecology and Organismal Biology, Columbus, USA; [5]Department of Food, Agricultural and Biological Engineering, Columbus, USA. **Fate of Microcystin in Crops and Soil during pre- and post-harvest.**

Microcystins (MCs) are the most common cyanotoxins in freshwater during cyanobacterial blooms. MCs exposure routes to humans via water and fish consumption are well-documented in previous studies, less is known about the potential MC exposure through consumption of vegetables that has been cultivated with MC-contaminated water. To examine risk related with cultivating crops with MC-contaminated water, we examined MC accumulation patterns in different types of vegetables and their surrounding soils. Crops, romaine lettuce, carrots, and green bean, were cultivated and exposed to environmentally relevant concentrations of MC-LR (1, 5, 10 μg/L) either drip or spray irrigation. The results show that MC-LR accumulation was positively dose-dependent, with it being greater in the plants than in the soil. MC-LR the accumulation levels varied with crop types (green beans > carrots > lettuce). The toxin also localized within a certain part of the plants (roots > shoots). The irrigation methods did not show significant influence on the toxin accumulation. The toxin remained in the soil for at least two months after harvest. The outcome of this study is useful for establishing guidelines for irrigation water quality. *Keywords: Human health, Vegetables, Toxic substances, Microcystin, Harmful algal blooms, Soil.*

LEE, S., JIANG, X., MANUBOLU, M., LUDSIN, S.A., MARTIN, J., and LEE, J., Ohio State University, Columbus, OH, 43210, USA. **Bioaccumulation of Microcystin in Vegetables: Impact on Food Quality and Human Health Risk.**

Freshwater cyanobacteria blooms have become a global concern, affecting many water bodies that are important water sources for drinking, recreation (swimming and fishing), and agriculture. While numerous studies focused on the safety of drinking and recreational water, there are very few concerning the impact of irrigation water on human health and food quality when the water is contaminated with cyanotoxins. The objectives of this study were to determine 1) the fate of microcystin (MC) in crops when irrigated with MC-contaminated water, 2) the effects of MC on the quality and productivity of crops, and 3) potential human health risk when ingesting the harvested crops. Three different vegetable types (romaine lettuce, carrots, and green bean) were cultivated using the water containing environmentally relevant concentrations of MC-LR (1, 5, 10 μg/L). MC-LR accumulation levels varied with crop types. The growth rate, quality, and yield of crops were adversely impacted by MC-LR. With the estimated daily consumption of vegetables, the MC intake was calculated. The result shows that the health risk from these vegetable intake is moderate to high when compared to the chronic reference dose and total daily intake guideline. Based on these findings, we recommend bloom-affected surface water to be monitored for agriculture use. *Keywords: Microcystis, Human health, Food safety, Harmful algal blooms.*

LEKKI, J.[1], ANDERSON, R.[1], AVOURIS, D.[2], BECKER, R.[3], CLINE, M.[3], LESHKEVICH, G.[4], LIOU, L.[1], LUVALL, J.[5], ORTIZ, J.[2], RUBERG, S.[4], SAWTELL, R.W.[6], SAYERS, M.J.[6], SCHILLER, S.[7], SHUCHMAN, R.A.[6], SIMIC, A.[8], STUART, D.G.[9], TOKARS, R.[1], and VANDER WOUDE, A.[9], [1]NASA Glenn Research Center, 21000 Brookpark Rd, Cleveland, OH, 44135, USA; [2]ent State University, 800 E Summit St, Kent, OH, 44240, USA; [3]University of Toledo, 2801 W Bancroft St, Toledo, OH, 43606, USA; [4]NOAA Great Lakes Environmental Research Lab, 4840 S State Rd, Ann Arbor, MI, 48108, USA; [5]NASA Marshall Space Flight Center, Huntsville, AL, 35811, USA; [6]Michigan Tech Research Institute, Michigan Technological University, 3600 Green Ct., Ste. 100, Ann Arbor, MI, 48105, USA; [7]South Dakota State University, Brookings, SD, 57007, USA; [8]Bowling Green State University, Bowling Green, OH, 43403, USA; [9]University of Michigan, CILER, 500 S State St, Ann Arbor, MI, 48109, USA. **Airborne Hyperspectral Imaging for monitoring Harmful Algal Blooms in Lake Erie.**

Harmful Algal Blooms (HABs) in Lake Erie has been prominent in recent years. The bloom in 2014 reached a severe level causing the State of Ohio to declare a State of Emergency. At that time NASA Glenn Research Center was requested by stakeholders to help monitor the blooms in Lake Erie. Using its hyperspectral imaging sensor in development since 2006, the S-3 Viking aircraft, and the flight resource from the NASA Headquarters Earth Science Division, GRC conducted twice weekly flights in the summer of 2015 and 2016 assembled and distributed the HAB information to the shoreline water resource managers. Airborne hyperspectral observation of HABs holds promise to delineate potentially harmful algal blooms from nuisance blooms, their concentration, and their movement in an augmented spatial and temporal resolution and under clouds--all are excellent complements to satellite observations. Working with collaborators, this effort was able to provide next day georeferenced estimates of cyanobacteria concentration and scum concentration. *Keywords: Remote sensing, Harmful algal blooms, Algae.*

LEMAIRE, M.[1], GUILLARD, J.[1], LOBRY, J.[2], and ANNEVILLE, O.[1], [1]INRA UMR CARRTEL, Thonon les Bains, FRANCE; [2]IRSTEA UR EABX Aquat Ecosyst and Global Changes, Cestas, FRANCE. **Sensitivity of lake food web structure and functioning to strong variations in fish abundances.**

Studies on the impacts of human induced disturbances on food webs have flourished over the past decades. In contrast, effects of natural fish demographic variability on the structure and functioning of food webs remain poorly documented. Some fish populations are indeed subjected to strong fluctuations in juveniles abundances. They can affect trophic links and these effects may propagate in the food web and modify its overall structure and functioning. In Lake Annecy (France), the abundance of the young of the year (YOY) perch (*Perca fluviatilis*) exhibits strong inter-annual fluctuations. The impact of YOY perch biomass variation on the structure and functioning of the oligotrophic Lake Annecy food web is analyzed using two mass-balanced Ecopath models. Each one describes respectively a year with high and low YOY perch biomass. In both models, the food web structure is similar and the functioning remains mainly based on detritus. Indeed, half of the flows are from detritus compartment, which is strongly related to zooplankton mortality at trophic level (TL) II. Finally, YOY perch plays a key role in transfer efficiency, high biomasses at TL II buffer the impacts of YOY perch fluctuations and have a stabilizing role on the structure of the food web. *Keywords: Ecosystem modeling, Food chains, Fish.*

LENTERS, J.D., University of Wisconsin-Madison, Center for Limnology, Boulder Junction, WI, 54512, USA. **Rapid Warming of the World's Large Lakes: Physical Mechanisms and Regional Perspectives.**

Recent studies have shown rapid warming of inland water bodies around the world. Many lakes and reservoirs are warming more rapidly than air temperature, including quite a few large, deep lakes, and this is counter to what is often expected based on the "thermal inertia" of lakes and the surface energy balance. Many reasons have been proposed to explain these discrepancies, including changes in the onset of summer stratification, loss of ice cover, and changes in winter air temperature or summer cloud cover. A review of the literature suggests that no single, physical mechanism is solely responsible for the majority of these changes, but rather that the large heterogeneity in regional climate trends and lake geomorphometry results in a host of potential physical drivers. Here, we discuss the variety of mechanisms that have been proposed to explain rapid lake warming and offer an assessment of the physical plausibility for each potential contributor. Lake Superior is presented as a case study to illustrate the "perfect storm" of factors that can cause a deep, dimictic lake to warm at a rate that exceeds the increase in global air temperature by nearly an order of magnitude. The results highlight a wide range of factors that lead to trends in lake temperature, and that conventional wisdom is often not the best guide. *Keywords: Lake Superior, Water temperature, Climate change, Physical limnology, Atmosphere-lake interaction.*

LEON, L., VALIPOUR, R., MCCRIMMON, C., and YERUBANDI, R., Environment Canada, Burlington, CANADA. **Multi-year lake modelling effects of climate change in Lake Erie.**

Under climate change scenarios, increases in air and water temperature are to be expected in the Great Lakes probably yielding to longer ice-free stratified seasons. Predictive models can show how changes in climate forcing can impact algal blooms and/or enhance the formation of hypoxia, particularly in the west and central basins of Lake Erie. As part of the climate change adaptation research program, we started the modelling effort by assembling a large meteorological dataset [2002-2014], mostly from over-the-lake observations (ECCC and NOAA bouys) and complemented from inland stations, as well as acquired near and end of the century climate change scenarios from regional climate models (CRCM5). This study presents preliminary results of long-term multi-year simulations with ELCOM (3D lake hydrodynamic model) of the thermal structure in Lake Erie with the current weather conditions and for those forecasted under future climate scenarios. *Keywords: Hydrodynamic model, Lake Erie, Climate change.*

LEONHARDT, B.S.[1], HÖÖK, T.O.[1], HAPPEL, A.[2], CZESNY, S.J.[2], TURSCHAK, B.A.[3], BOOTSMA, H.A.[3], RINCHARD, J.[4], KORNIS, M.S.[5], and BRONTE, C.R.[5], [1]Purdue University, Department of Forestry and Natural Resources, 195 Marsteller St, Lafayette, IN, 47907, USA; [2]University of Illinois, Illinois Natural History Survey, Lake Michigan Biological

Station, 400 17th Street, Zion, IL, USA; [3]School of Freshwater Sciences, University of Wisconsin-Milwaukee, 600 E Greenfield Ave, Milwaukee, WI, USA; [4]State University of New York Brockport, Department of Environmental Science and Biology, 350 New Campus Drive, Brockport, NY, USA; [5]US Fish and Wildlife Service, Green Bay Fish and Wildlife Conservation Office, 2661 Scott Tower Drive, New Franken, WI, WI, 54229, USA. **Prey Species- and Size-Specific Consumption by Lake Michigan Piscivores.**

Invasive alewives (Alosa psuedoharengus) have been an important diet item for salmonids in Lake Michigan for the last 50 years, especially for Chinook (Oncorhynchus tshawytscha) and Coho salmon (Oncorhynchus kisutch). However, over the past twenty years alewife densities, growth rates, and condition have declined, evidently due to high predation pressure from salmonids and reduced pelagic production and invertebrate prey availability. Concurrently, another invasive forage species, round goby (Neogobius melanostomus), has increased in abundance and become the second most common prey for some salmonids in Lake Michigan. We evaluated of Lake Michigan piscivores by forage species, region and season using stomach content analyses. In addition, we examined size-specific consumption and the potential for individual specialization on specific prey species or sizes of prey. Collectively, alewife and round goby now constitute 99% of prey fish consumed by weight by the five main salmonid species in the lake. The long-term sustainability of this predator-prey system may depend not only on tempering overall predation pressure, but also the partitioning of prey resources by species and size. We will summarize these findings and discuss their implications in the context of sustainable fisheries. *Keywords: Diet specialization, Lake Michigan, Salmonids, Alewife, Round goby.*

<u>LEPAK, R.L.</u>[1], YIN, R.[2], JANSSEN, S.E.[3], KRABBENHOFT, D.P.[3], OGOREK, J.M.[3], DEWILD, J.F.[3], TATE, M.T.[3], HOLSEN, T.M.[4], and HURLEY, J.P.[5], [1]University of Wisconsin-Madison, Environmental Chemistry and Technology Program, 660 North Park Street, Madison, WI, 53706, USA; [2]State Key Laboratory of Ore Deposit Geochemistry, Guiyang, CHINA; [3]United States Geological Survey, Wisconsin Water Science Center, 8505 Research Way, Middleton, WI, 53562, USA; [4]Department of Civil and Environmental Engineering, Clarkson University, Potsdam, NY, 13699, USA; [5]University of Wisconsin-Madison, Aquatic Science Center, Madison, NY, 53706, USA. **Use of Mercury Stable Isotope Signatures to Ascertain Sources to Piscivorous Great Lake's Fish.**

A goal of the Great Lakes Restoration Initiative is to reduce mercury (Hg) levels in Great Lake fish. Methylmercury (MeHg), the most toxic and bioaccumulative form of Hg, is the predominant form in fish tissue. The ability to ascertain Hg sources, the relative bioavailability of those sources, and key processes controlling bioaccumulation in fish is critical to management. Previous use of Hg stable isotopes in sediments of the Great Lakes

allowed for the quantitative identification of Hg source portfolios for each lake. We apply a similar approach to identify isotopically distinct Hg signatures in Great Lakes' piscivorous fish. Piscivorous fish spanned a large range of Δ^{199}Hg (2.27 - 6.73‰). This may be explained by differences in euphotic depth (2-43m) among the Great Lakes, a region where Hg and MeHg may be entering the base of the aquatic food web. Signatures of even mass independent fractionation (MIF), a potential binary tracer for precipitation sources, appears to be disconnected from local sedimentary sources in fish tissue, and is comparable in magnitude across the Great Lakes. The use of multiple MIF Hg signatures allow us to evaluate the influence of atmospheric Hg sources on bioaccumulation and compare the degree of photochemical processing of Hg in the Great Lakes. *Keywords: Isotope studies, Mercury, Fish.*

LEPAK, R.L.[1], HOFFMAN, J.C.[2], JANSSEN, S.E.[3], KRABBENHOFT, D.P.[3], OGOREK, J.M.[3], DEWILD, J.F.[3], BABIARZ, C.L.[3], TATE, M.T.[3], YIN, R.[4], MURPHY, E.W.[5], and HURLEY, J.P.[6], [1]University of Wisconsin-Madison, Environmental Chemistry and Technology Program, 660 North Park Street, Madison, WI, 53706, USA; [2]United States Environmental Protection Agency, Office of Research and Development, Duluth, MN, 55804, USA; [3]United States Geological Survey, Wisconsin Water Science Center, 8505 Research Way, Middleton, WI, 53562, USA; [4]State Key Laboratory of Ore Deposit Geochemistry, Guiyang, CHINA; [5]United States Environmental Protection Agency, Great Lakes National Program Office, Chicago, IL, 60604, USA; [6]University of Wisconsin - Madison, Aquatic Sciences Center, Madison, WI, 52706, USA. **Changes in Stable Isotope Composition in Lake Michigan Trout - a 40 year perspective.**

Researchers have frequently sought to use environmental archives of sediment, peat and glacial ice to assess historical trends in atmospheric mercury (Hg) deposition to aquatic ecosystems. We propose the use of fish archives and Hg stable isotopes as an improved means to relate temporal changes in fish Hg levels to varying Hg sources in the Great Lakes. Hg concentrations span a large range (1,600 to 150 ng g^{-1}) and exhibit large variations from 1975 to 1985. Δ^{199}Hg signatures exhibit large variation (3.2 to 6.9‰) until 1985, followed by less variation through the end of the data record in 2014. δ^{202}Hg showed a relatively consistent value of about 0.4 - 0.8‰ from 1975 to 1988, followed by a significant ($p<0.0001$) shift of about 0.7‰ between 1989 and 1996, with relative stability through the end of the record (1.2 - 1.6‰). This isotope shift may be linked to a combination of the contemporaneous implementation of Clean Air Act rules limiting Hg emissions from waste incineration and to changes in carbon cycling resulting from invasive mussels. We propose a dietary convergence in trout Hg isotope values is observable following the onset of mussel invasion. We suggest that with the combined use of Hg, C and N stable isotopes, we can trace temporal changes in Hg sources to fish. *Keywords: Mercury, Stable isotopes, Fish.*

LESHKEVICH, G.[1] and LIU, S.[2], [1]NOAA/Great Lakes Environmental Research Laboratory, 4840 South State Road, Ann Arbor, MI, 48108, USA; [2]Cooperative Institute for Limnology and Ecosystems Research, 440 Church Street, Ann Arbor, MI, 48109, USA. **Great Lakes CoastWatch - New Data Sets and New Data Servers.**

CoastWatch is a nationwide National Oceanic and Atmospheric Administration (NOAA) program within which the Great Lakes Environmental Research Laboratory (GLERL) functions as the CoastWatch Great Lakes regional node. In this capacity, GLERL obtains, produces, and delivers environmental data and products for near real-time monitoring of the Great Lakes to support environmental science, decision making, and supporting research. This is achieved by providing Internet access to near real-time and retrospective satellite observations, in-situ data, and derived products to Federal and state agencies, academic institutions, and the public via the CoastWatch Great Lakes web site (https://coastwatch.glerl.noaa.gov). New image products include chlorophyll, CDOM, DOC, suspended mineral, upwellings, and ice types. New data sets include the Great Lakes Optical Properties Geospatial Database (GLOPGD) and long-term surface water temperatures with winter ice cover in ascii gridded format. A new CoastWatch server running THREDDS (Thematic Real-time Environmental Distributed Data Services) and ERDDAP (Environmental Research Division's Data Access Program), a data server that gives you a simple, consistent way to download gridded and tabular scientific datasets in common file formats, are also available, as well as the RealEarth™ map server.
Keywords: Remote sensing, Water quality, Data storage and retrieval.

LESHT, B.M.[1], BARBIERO, R.P.[2], WARREN, G.J.[3], and WARNER, D.M.[4], [1]CSRA and UIC, 845 W. Taylor Ave., Chicago, IL, 60607, USA; [2]CSRA, 1359 W. Elmdale, Chicago, IL, 60660, USA; [3]USEPA/GLNPO, 77 W. Jackson, Chicago, IL, 60605, USA; [4]USGS/GLSC, Ann Arbor, MI, USA. **Assessing Methods Used to Estimate Photic Depth in the Great Lakes from Satellite Observations.**

Because it defines the vertical extent of the zone of active photosynthesis, an estimate of the photic depth (Zeu), the level in the water column at which light intensity is reduced to 1% of the intensity just below the surface, is a critical component of both depth resolved and vertically integrated models of primary production. In recent years primary production models have become more highly resolved in both space in time, therefore it has become necessary to make estimates of Zeu at the same spatial and temporal scales. In large bodies of water such as the Great Lakes, satellite remote sensing is the only practical method available to meet this need, but the algorithms used for estimating Zeu from satellite observations have not been rigorously tested in the Great Lakes. In this study, we used measurements of the vertical profile of photosynthetically available radiation (PAR) collected between 2003-2015 as part of the U.S. EPA's, Great Lakes National Program Office (GLNPO) annual monitoring program to estimate Zeu. We compared the field measurements to estimates of satellite-derived Zeu obtained from several published algorithms ranging from simple empirical relationships to more complicated ones based on the inherent optical properties of the water. The results are interesting and you should come to the talk. *Keywords: Model testing, PAR, Remote sensing, Attenuation, Photosynthesis, Photic depth.*

LI, A.[1], ROCKNE, K.J.[2], STURCHIO, N.[3], GIESY, J.P.[4], WANG, Y.W.[5], GUO, J.H.[1], LI, Z.N.[1], RANASINGHE, P.[1], HOSSEINI, S.[2], BONINA, S.M.C.[2], CORCORAN, M.B.[3], CODLING, G.[4], SMALLEY, C.[3], and CAO, D.D.[5], [1]School of Public Health, University of Illinois at Chicago, 2121 W. Taylor Street, Chicago, IL, 60612, USA; [2]Department of Civil and Materials Engineering, University of Illinois at Chicago, 842 West Taylor Street, Chicago, IL, 60607, USA; [3]Department of Earth and Environmental Sciences, University of Illinois at Chicago, 845 W. Taylor Street, Chicago, IL, 60607, USA; [4]Department of Veterinary Biomedical Sciences and Toxicology Centre, University of Saskatchewan, 44 Campus Drive, Saskatoon, SK, S7N 5B3, CANADA; [5]Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, 18 Shuang-Qing Road, Beijing, 100049, CHINA. **Tracking Organic Chemical Pollution of Upper Great Lakes from Sedimentary Records.**

The Great Lakes Sediment Surveillance Program (GLSSP) was established in 2010. From Lakes Superior, Michigan, and Huron, a total of 28 cores (>500 core segments) and 112 Ponar surface grab sediment samples were collected from 2010-2012. All samples were characterized and the cores were dated. Organic pollutants have been analyzed, including polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs), polychlorinated biphenyls (PCBs), polychlorinated diphenyl ethers (PCDEs), polychlorinated naphthalenes (PCNs), organochlorine pesticides (OCPs), polybrominated diphenyl ethers (PBDEs), novel halogenated flame retardants (nXFRs), organophosphate flame retardants (OPFRs), poly- and per-fluorinated compounds (PFCs), and a number of musk fragrances (MFs). Atrazine and structurally similar compounds were not initially targeted but found. The data have been used to estimate lake-wide burden and annual loading of the chemicals in sediment, with expectedly higher accuracies than those from our previous studies that used much less numbers of sampling sites. The spatial distribution patterns revealed pollution hotspots and provided evidence of long range transport; and the temporal trends from cores showed downward diffusion of relatively hydrophilic compounds and the occurrence of long term in situ transformation of some compounds. *Keywords: Sediments, Temporal trend, Toxic substances, Organic pollutants, Spatial distribution.*

LI, J.J., HAFFNER, G.D., and DROUILLARD, K.G., Great Lakes Institute for Environmental Research, University of Windsor, 401 Sunset Ave, Windsor, ON, N9B 3P4, CANADA. **Relative importance of tissue growth rate on Hg and PCB dynamics in fish.**

To evaluate the effect of tissue growth rate on mercury (Hg) and polychlorinated biphenyls (PCBs) bioaccumulation, multiple age classes of bluegills (*Lepomis macrochirus*) were collected from Apsey lake, Sharbot Lake, the Detroit River, Stonelick Lake, and Lake Hartwell. The five water bodies were chosen because they are located at latitudes with different climates that lead to varying growth scenarios. The daily and average water temperature were estimated for each water body based on air temperature. The food consumption, respiration, fecal egestion, and chemical elimination rates were estimated by a Wisconsin bioenergetics model. Hg and PCB concentrations were simulated for each population by a toxicokinetic model using bioenergetics parameters based on daily water temperature, and actual measurements of tissue growth. Similar simulations were also performed using bioenergetics parameters derived by constant water temperature, as well as using tissue growth rate which was set to a constant proportion of whole body growth. Two hypotheses were tested by this study: 1) The use of actual tissue growth rates can generate stronger predictions for Hg and PCB concentration in fish compared to whole body growth rates; 2) Using daily water temperature can generate stronger predictions compared to using constant temperature. *Keywords: Bioaccumulation, PCBs, Modeling, Mercury.*

LI, L. and SEO, Y., The University of Toledo, 3031 Nitschke Hall, 2801 W. Bancroft Street, Toledo, OH, 43606, USA. **The Influence of Algal Organic Matter on Biofilm Development and Disinfection By-product Formation.**

In drinking water distribution systems (DWDS), natural organic matter (NOM) is an important environmental factor to influence the life of biofilm. Recently, autochthonous NOM (i.e. algal organic matter (AOM)) originated from algae has been received great attentions due to the eutrophication issues in many freshwater systems. AOM may deteriorate the drinking water quality by supporting biofilm regrowth in DWDS and reacting with disinfectants to form harmful disinfection by-products (DBPs). However, currently, it is still not well understood how the AOM in source water influences biofilm formation, and later affects DBP levels in the DWDS. This study examined the effects of algal organic matter on biofilm development and DBP formation in simulated DWDS with PVC pipe material for six months. PVC coupons from simulated DWDS were periodically taken to monitor both biofilm structure and DBP formation potential of biofilms. Multiple analytical techniques, such as confocal laser scanning microscope, and excitation emission matrix fluorescence with parallel factor analysis (EEM-PARAFAC) were applied to characterize biofilm development patterns and NOM changes. Then, all obtained NOM analysis results were further correlated with both carbonaceous and nitrogenous DBP formation potential of biofilm. *Keywords: Algae, Disinfection by-product, Lake Erie, Biofilm development, Organic compounds.*

LI, Y., BENCE, J.R., and BRENDEN, T.O., Quantitative Fisheries Center, Department of Fisheries and Wildlife, Michigan State University, 480 Wilson Road, Room 13, East Lansing, MI, 48824, USA. **A Comprehensive Framework for Modeling Spatial Tag-Recovery Data With Different Movement Assumptions.**

We developed and applied a comprehensive tagging model framework for modeling multiyear tag-recovery data in a fishery context. Our framework made use of conventional tag-recovery, catch-at-age, and observer data, and allowed for different assumptions about spatial structure, including both diffusion and overlap models. Previous extensions of tagging models for spatial structure have assumed that fish start moving from where they were in the last time period (i.e., diffusion model). Such spatial assumptions do not reflect the life history of many economically and ecologically important Great Lakes fish species, such as lake whitefish (*Coregonus clupeaformis*) and walleye (*Sander vitreus*), which are known to exhibit a high degree of spawning site fidelity. As a case study, we applied our model framework assuming an overlap spatial structure to lake whitefish tag-recovery data collected from Lake Huron from 2003 to 2011. Preliminary results suggest that spawning populations in the U.S. main basin had a higher probability to overlap with other populations during the fishing season, compared to those in Canadian waters. Tag reporting rates in the central and southern U.S. main basin were much lower than those in other regions of Lake Huron. *Keywords: Tagging model, Spatial structure, Statistical catch-at-age.*

LINARES, A.[1], WU, C.H.[1], ANDERSON, E.J.[2], and CHU, P.[2], [1]University of Wisconsin, Madison, Madison, WI, 53706, USA; [2]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, USA. **Role of meteorologically-induced water level oscillations on Contaminated Sediment Transport.**

Contaminated sediments are a significant environmental problem that impairs the uses of many water bodies nationwide. As in most AOCs, sediment transport in Manistique River (MR) is subjected to flood flows and meteorologically-induced water level. These lake oscillations are known as seiches when their period is longer than 2h and meteotsunamis when their period range from a few minutes to 2h. In this talk, we reveal transport of contaminated sediments inside the harbor caused by meteotsunamis, seiches, and flood flows. Bottom shear stresses induced by meteotsunamis, seiches, and floods can exceed the critical condition to resuspend bottom sediments even in a deep water environment. The oscillatory nature of meteotsunamis and seiches can temporarily reverse flow in the MR and transport contaminated sediments upstream to previously cleaned areas. Results indicate that while flood flows are the main cause of sediment transport in the main stream, meteotsunamis are the primary cause of resuspension and flushing of contaminated sediments, which are usually located outside the main stream. Overall the outcomes of this study aid to address the sustainable remediation of river-estuary AOC of the Great Lakes. *Keywords: Environmental contaminants, Atmosphere-lake interaction, Sediment resuspension.*

LIU, J.[2], BASU, N.B.[2], WELLEN, C.C.[1], SELLIER, W.[2], TO, A.[2], VAN CAPPELLEN, P.[2], and MOHAMED, M.N.[3], [1]University of Windsor, Windsor, ON, CANADA; [2]University of Waterloo, Waterloo, ON, CANADA; [3]Ontario Ministry of the Environment and Climate Change, Toronto, ON, CANADA. **A cross scale meta-analysis of the effectiveness of agricultural conservation measures.**

A number of conservation measures have been devised to control the loss of nutrients from agricultural areas to streams. Demonstrating the efficacy of agricultural conservation measures is a difficult technical challenge, and typically involves monitoring at the field scale and use of simulation models at the watershed scale. This talk will present the results of a review and meta-analysis that compares the effectiveness of agricultural conservation measures estimated with field and watershed scale monitoring data and watershed models. Data from roughly 100 studies published during the past five years have been compiled. Analysis reveals that there are statistically significant differences in conservation effectiveness as estimated by watershed models and field monitoring data. This difference is however of a small magnitude, with model-estimated median nutrient yield reductions of 18% and field data estimated median nutrient yield reductions of 25%. This talk compares modelled and measured efficacy for different types of conservation measures (transport and source controls) and quantifies the relationship of nutrient yield reduction to various other study attributes, including nutrient application rates and crop yield. To conclude, we highlight certain data gaps located and key model uncertainties typically not addressed. *Keywords: Watersheds, Agriculture, Ecosystem modeling, Water quality.*

LIU, L., CHOI, O., and SEO, Y., The University of Toledo, 2801 W. Bancroft St., toledo, OH, 43606, USA. **Adsorption of MC-LR onto water supply pipe materials.**

Even after the Do Not Drink water advisory was lifted for the City of Toledo, both city residents and regional residents that received water from the City still had great concern

over water quality in the miles-long water distribution system and buildings. While significant emphasis has been placed on removing cyanotoxins at the water treatment plant, the transport and fate of cyanotoxins within the water distribution system is not completely understood. Thus, this study investigates the adsorption kinetics of microcystins on different water supply pipe materials (polyvinyl chloride (PVC), polypropylene (PP), polyethylene (PE), and iron with or without corrosion) under relevant conditions in water distribution systems (pH, varying organic matrix, etc.). Single, binary, and quaternary isotherm tests were conducted to assess the competitive effects of natural organic matter (NOM) on the microcystin adsorption. After conducting batch isotherm tests, adsorption isotherm models were also used to quantify adsorption capacity and intensity of tested pipe materials.
Keywords: Toxic substances, Microcystin-LR, Water distribution, Adsorption, Algae, Water pipe material.

LIU, Q.[1], ANDERSON, E.J.[2], and BIDDANDA, B.A.[1], [1]Grand Valley State University, Muskegon, MI, USA; [2]NOAA-Great Lakes Environmental Research Laboratory, Ann Arbor, MI, USA. **A Physical-Biogeochemical Simulation of Muskegon Lake.**

The Muskegon Lake estuary, on the eastern shore of Lake Michigan, is a designated EPA AOC and a NOAA Habitat Blueprint focus area. The lake experiences harmful algal blooms and hypoxia, which arises from anthropogenic nutrient input and in return affects human activities. Although long-term monitoring of the lake provides valuable information for investigating the ecosystem, limitations in the available data make it difficult to understand the processes driving bloom formation, hypoxia, and exchange with Lake Michigan. To better understand the physical-biogeochemical processes in Muskegon Lake and to assist ecosystem-based management, we are developing a coupled physical-biogeochemical model to systematically investigate the ecosystem in Muskegon Lake.
Keywords: Ecosystem modeling, Water quality, Hydrodynamics.

LOFGREN, B.M.[1] and XIAO, C.[2], [1]NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Road, Ann Arbor, MI, 48108, USA; [2]Cooperative Institute for Limnology and Ecosystems Research, 4840 S. State Road, Ann Arbor, MI, 48108, USA. **Influence of Greenhouse Gas Concentrations on Lake Phenology and Temperature Profiles.**

Future climates under higher concentrations of greenhouse gases are expected to feature higher air and water temperatures. We investigate in greater detail the evolution of this in terms of the annual cycle of lake temperature profiles, stratification, and ice formation. Other work has found that, although shallower water promotes more rapid changes in surface water temperature within a season, change in surface water temperature across decades is more prominent in locations with greater water depth. Our simulations using the Weather Research and Forecasting (WRF) model and its lake module, WRF-Lake, show a trend toward longer periods of summer stratification, both through earlier onset in the spring and later decay of stratification in the fall. They also show a general increase in temperature throughout the water column, but most pronounced near the surface during the summer. Likewise, ice duration is much shorter and more restricted to shallow embayments. The timing and duration of stratification will influence biotic activity through the timing of vertical mixing of nutrients and oxygen. Sources of uncertainty are cumulative--actual future greenhouse gas concentrations, global sensitivity of climate change, cloud feedbacks, and the combined formulation of the regional climate model (WRF) and its global driving mode. *Keywords: Climate change, Lake temperature, Stratification.*

LONG, C.M.[1], MUENICH, R.L.[1], KALCIC, M.M.[2], and SCAVIA, D.[1], [1]University of Michigan, Ann Arbor, MI, USA; [2]Ohio State University, Columbus, OH, USA. **Impacts of Concentrated Animal Feeding Operations and Manure on Nutrient Inputs in a Watershed.**

Multiple studies have demonstrated that agricultural nonpoint source pollution from a combination of inorganic fertilizer and manure is the major source of phosphorus that drives harmful algal blooms in the Western Lake Erie Basin (WLEB). The precise contributions and impacts of manure alone, however, remain unknown. There recently has been increasing interest from agricultural and environmental groups as well as from policymakers about the effects of manure applications, especially in the WLEB. The impacts of Concentrated Animal Feeding Operations (CAFOs) have been of particular concern as, over the past few decades, there has been a nationwide trend toward larger animal operations and away from small farms. We therefore seek to better understand the details of manure amounts, compositions, and application at CAFOs, and evaluate the effects that CAFOs can have on nutrient loadings in a watershed. We use the River Raisin Watershed (RRW), which drains into the WLEB in southeast Michigan, as a case study to address these objectives. Here we present a synthesis of publicly available CAFO data from the RRW and discuss potential effects of manure applications on nutrient inputs and loads in the watershed. *Keywords: Watersheds, Agriculture, Nutrients.*

LOOI, A.H.R.[1], STOCKWELL, J.D.[1], ANNEVILLE, O.[2], PATIL, V.[3], GAEL, D.[4], and RUSAK, J.[5], [1]University of Vermont, Burlington, VT, USA; [2]French Institute for Agricultural Research, Thonon les Bains, FRANCE; [3]United States Geological Survey, Anchorage, AK, USA; [4]Shizuoka University, Shizuoka, JAPAN; [5]Dorest Environmental Science Centre, Dorest, ON, CANADA. **Can phytoplankton weather the storm? Assessing how phytoplankton communities change after storms.**

Storms are expected to become stronger, longer, and more common because of climate change. Because of storm influence on the thermal, dissolved oxygen, light, and nutrient environments within lakes, storms may represent significant environmental disturbances which, alter phytoplankton niche-space and community. To date, however, research specifically relating the links among storms, lake physics, phytoplankton traits and ecosystem function remains limited. The international collaboration GLEON "Storm-Blitz" is conducting analyses on traditional long-term and novel high-frequency datasets from lakes across the globe to better understand the patterns, mechanisms, and ecological implications of storms on phytoplankton communities. We have assembled data from over 25 lakes with some datasets > 40 years. Here, we develop a conceptual model to frame a working definition of 'storm' in relation to impacts on attributes of lake physics relevant to the biology of phytoplankton across a gradient of lake sizes, present preliminary data analyses to evaluate our model and our working definition of 'storm', and test the links between storms and phytoplankton trait-responses. *Keywords: Biodiversity, Storms, Algae, Wind.*

LOOMIS, M.[2], SCHOFIELD, J.[1], RAHIM, Z.[1], JANNELLE, N.[1], BLUME, L.J.[2], MILLER, K.[1], MASRI, S.[1], and HUMBERT, W.[1], [1]CSRA, 6361 Walker Lane, Suite 300, Alexandria, VA, 22310, USA; [2]US EPA Great Lakes National Program Office USEPA REGION 5, 77 West Jackson Boulevard, Chicago, IL, 60604-3507, USA. **Data Synthesis Tools for Evaluating Progress and Planning Restoration of Areas of Concern.**

The Great Lakes Legacy Act (GLLA) was enacted to facilitate cleanup of contaminated sediments in AOCs. The program has made significant progress by leveraging nonfederal funding to remediate over 4 million cubic yards of contaminated sediment since 2004. The data collected for contaminated sediment projects are complex and data analysis must address spatial and temporal variability, as well as a variety of media types. EPA developed tools, based on GeoPlatform, to synthesize and visualize these complex data for assessing site conditions, evaluating progress, planning future actions, and making sound decisions. EPA's GeoPlatform is the framework for coordinating the Agency's geospatial activities. This web mapping service allows EPA to use the ESRI-hosted infrastructure in a secure cloud-based environment. EPA integrated the Geoplatform with the Great Lakes Sediment Database which serves as the master repository for GLLA project data including sediment, water, and tissue chemistry data. The integrated system provides the ability to: 1) prepare maps for distribution to stakeholders; 2) compare sampling locations and results to inform subsequent phases of a project such as sampling gaps; 3) provide a forum to view data and discuss project planning amongst stakeholders; and 4) download the queried data in a spreadsheet. *Keywords: Decision making, Data storage and retrieval, Sediments.*

LOPEZ, L.S.[1], HEWITT, B.A.[1], SHARMA, S.[1], and MAGNUSON, J.J.[2], [1]York University, 4700 Keele St, Toronto, ON, M3J 1P3, CANADA; [2]University of Wisconsin-Madison, Center for Limnology, 680 N Park St, Madison, WI, 53706, USA. **The effects of climate change on lake ice break-up across the Northern Hemisphere.**

Lake ice phenology is highly sensitive to changes in climate. Long-term ice phenology records can serve as an important indicator of climate dynamics over time. Our objective was to determine the historical changes in ice break-up trends from 1951-2014 in 137 lakes across the Northern Hemisphere. We obtained ice phenology data from the Lake Ice Analysis Group (LIAG) and updated records from international collaborators. Across the Northern Hemisphere, we found that lake ice broke on average 8 days earlier since 1951 ranging from 2 days later to 25 days earlier during the indicated time period. We also found that 22% of lakes had up to three significant breakpoint years in their records, suggesting years of abrupt changes in trends. The most common breakpoint years were 1972, 1988, 1997 and 1998 among the lakes. These years corresponded to strong and very strong El Nino events as well as a shift to the positive phase of the Arctic Oscillation, North Atlantic Oscillation and Pacific Decadal Oscillation. Further, we found that a combination of air temperature, precipitation, cloud cover and large-scale climate drivers were driving earlier lake ice break-up. Under scenarios of climate change, we forecast that lake ice break-up will be earlier in the spring, leading to consequences in lake ecosystem structure and function.
Keywords: Ice, Climate change, Modeling.

LOUGHNER, J.L.[1], CHIOTTI, J.A.[1], BRIGGS, A.S.[1], ROSEMAN, E.F.[2], WILLS, T.C.[3], DROUIN, R.[4], BENOIT, C.[4], and BOASE, J.C.[1], [1]U.S. Fish and Wildlife Service Alpena FWCO - Waterford Substation, Waterford, MI, USA; [2]U.S.G.S. Great Lakes Science Center, Ann Arbor, MI, USA; [3]Michigan DNR Lake St. Clair Fisheries Research Station, Harrison TWP, MI, USA; [4]Ontario Ministry of Natural Resources and Forestry - Lake Erie Management Unit, London, ON, CANADA. **Using multiple gear types to assess the fish community in the St. Clair - Detroit River System.**

The St. Clair-Detroit River System (SCDRS) is an economically, environmentally, and recreationally important resource that connects Lake Huron to Lake Erie. To measure progress toward restoring ecosystem integrity in this system, numerous monitoring and assessment programs have been employed. With over 69 different fish species, effectively sampling the diverse adult and juvenile fish communities needs to be synergistic across jurisdictions and agencies, efficiently utilizing time and resources. Between 2011 - 2016, we evaluated the effectiveness of seven different gear types (setlines, gill nets, fyke nets, trawls, minnow traps, seines, and boat electrofishing) to determine fish community composition in near shore (<3 m) and deep water (>3 m) areas of the SCDRS. Catch was compared

seasonally and nonmetric multidimensional scaling (NMDS) was used to determine clusters of specific taxonomic groups sampled by each gear. Species richness was greatest for seines (54) followed by fyke nets (47), night electrofishing (46), gill nets (36), trawls (25), minnow traps (22) and then setlines (9). All gear captured unique species aside from setlines, with seining capturing the most (12). This analysis highlights the importance of gear selection and effectively allocating sampling resources when developing a long-term monitoring program.
Keywords: Detroit River, St. Clair River, Species composition.

LOVALL, S.[1], BLICHARSKI, T.[1], BURNS, R.L.[1], BOHLING, M.E.[2], EVANOFF, P.[3], and O'MEARA, J.[4], [1]Friends of the Detroit River, 20600 Eureka Rd., Ste 313, Taylor, MI, 48180, USA; [2]Michigan Sea Grant, 15100 Northline Rd. Suite 200, Southgate, MI, 48195, USA; [3]SmithGroupJJR, 201 Depot St., Ann Arbor, MI, 48104, USA; [4]Environmental Consulting & Technology, Inc, 2200 Commonwealth Blvd., Suite 300, Ann Arbor, MI, 48105, USA. **Habitat Restoration in the Detroit River Area of Concern.**

In 2013, the Public Advisory Council (PAC) for the Detroit River Area of Concern (AOC) developed a guidance plan that identifies targeted projects requiring completion in order to remove habitat related beneficial use impairments (BUIs) associated with the AOC - namely: Degradation of Fish and Wildlife Populations and Loss of Fish and Wildlife Habitat. This document describes historical issues, population impairments, and criteria for restoration project selection. It has become the organizing framework leading toward delisting the Detroit River as an AOC. Ten restoration projects are identified in the plan. All but two are in some stage of progress. Four other projects are noted as already completed. Reference to this guidance document is standard language in all funding applications for habitat restoration work in the Detroit River, which has resulted in great success. The Friends of the Detroit River (fiduciary for many Great Lakes Restoration Initiative projects) was recently selected to receive a "Partnership Grant" with NOAA to develop most of the remaining targeted projects in the Detroit River in addition to some in the Rouge River. This presentation provides historical background about the Detroit River's degradation and an introduction to completed, on-going and planned habitat restoration projects.
Keywords: Detroit River, Habitat restoration, Fish populations.

LOWE, S.E., NOAA Marine Debris Program/Freestone, Oak Harbor, OH, USA. **Progress Summary of the Great Lakes Marine Debris Action Plan.**

Marine debris is any persistent solid material that is manufactured or processed and directly or indirectly, intentionally or unintentionally, disposed of or abandoned into the marine environment or the Great Lakes. Throughout the Great Lakes, marine debris threatens wildlife, natural resources, and the environment. Coordinated by NOAA and

launched in 2014, the *Great Lakes Land-based Marine Debris Action Plan* is bringing science, government, industry and NGOs together in a regional partnership to clean up the Great Lakes. The plan's five-year goal: to research the problem of marine debris, guide science-based policies and management decisions, and coordinate actions to prevent and reduce marine debris. The action plan consists of 53 actions which are to be completed within five years (2014-2019). During the first three years of the plan, contributors to the *Great Lakes Land-based Marine Debris Action Plan* began work on 32 actions and successfully completed 11 actions. Ten actions will be started in the future. Information presented will include progress highlights as well as the plan's alignment with other national and international efforts on marine debris. *Keywords: Microplastics, Marine debris, Planning, Pollutants.*

LUCIER, H.M.[1], HAWLEY, N.[2], and CHU, P.[2], [1]Cooperative Institute for Limnological and Ecosystems Research, 4840 S. State Rd., Ann Arbor, MI, 48108, USA; [2]Great Lakes Environmental Resarch Laboratory, 4840 S. State Rd., Ann Arbor, MI, 48108, USA. **Developing a long-term database of water temperature measurements in the Great Lakes.**

Over the past 50 years numerous time series measurements of water temperatures in the Great Lakes have been made. These data provide an excellent source for the initialization, verification and assimilation of numerical models but their use is limited by a lack of metadata, consistency and availability. The NOAA Great Lakes Environmental Research Laboratory is in the process of developing a comprehensive, long-term database that includes time series measurements of water temperatures made by the laboratory since its founding in 1976 as well as any other data that can be found. The available data and metadata creation process will be described. We seek knowledge of data from other sources to include in the database with the hope that such comprehensive water temperature database with proper metadata could benefit researchers in the Great Lakes community in improving numerical modeling and long-term climate studies. *Keywords: Climatic data, Great Lakes basin, Model testing.*

LUYMES, N.W., MARKLE, C.E., and CHOW-FRASER, P., McMaster University, Hamilton, ON, CANADA. **Use of Salamanders as Indicators of Ecological Effects of Climate Change in Southern Ontario Forests.**

The high sensitivity of salamanders to environmental disturbances makes them valuable indicators of current and future ecological threats. In forest ecosystems surrounding the great lakes, salamanders make up a large proportion of the vertebrate biomass and are an important prey item for other vertebrates. Salamanders require moisture for survival and reproduction, so environmental changes that reduce the amount and occurrence of moisture

throughout forests are expected to have a negative impact on salamander populations. Climate change in particular is expected to decrease annual precipitation and increase durations of droughts. We analysed trends in salamander abundance from an 18-year monitoring dataset in the Long Point Biosphere Reserve to investigate the effect of changing climate conditions on populations of terrestrial (Plethodontid) and aquatic (Ambystomatid) breeding salamanders. We will determine the feasibility of using abundance of forest dwelling salamanders as potential indicators of the long-term effects of climate change. We will identify habitats within forest reserves that are no longer suitable for salamanders, presumably because of altered hydroperiods associated with climate change, so that environmental managers can target these areas for rehabilitation and/or mitigation.
Keywords: Monitoring, Climate change, Amphibians.

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MA, J.R., Chongqing Institute of Green and Intelligent Technology, Chinese Academy of Sciences, NO 266, Fangzheng road, Chongqing, Cq, 400714, CHINA. **Three Gorges Reservoir: Has water quality improved in the 20 years since impoundment?**

Reservoirs provide an essential service to human populations, enabling water storage and development, however they also have some negative environmental impacts. The Three Gorges Reservoir in the upper Yangtze River is remarkable in the world for its size and engineering. Data from monitoring and socio-economic development between 1994 and 2013 has indicated that water quality has improved since impoundment of water in the mainstream Three Gorges Reservoir. The main causes for water quality improvement include catchment pollution control and characters of this reservoir including flow speed decrease, anti-seasonal operation and dilution, which were benefit enlarge eco-environment capacity. However, algal blooms in backwater zones of the tributaries were becoming more frequent. Long-term eco-environmental protection of this reservoir is paramount to control eutrophication in tributaries and ensure the maintenance of water quality. *Keywords: Water quality, Eutrophication, Algal blooms.*

MAAVARA, T., SLOWINSKI, S., VAN METER, K.J., REZANEZHAD, F., and VAN CAPPELLEN, P., Ecohydrology Research Group, Earth and Environmental Sciences, University of Waterloo, 200 University Ave W, Waterloo, ON, N2L 3G1, CANADA. **Spatiotemporal drivers of Si:P stoichiometry in the Grand River Watershed, Ontario, Canada.**

The Grand River (GR) is the largest Canadian tributary to Lake Erie. Historically, both the Grand River and Lake Erie have been considered stoichiometrically P-limited, where the molar silicon to phosphorus (Si:P) ratio is greater than the ~16:1 phytoplankton uptake ratio. However, recent trends suggest that eastern Lake Erie may be approaching Si-limitation. Large moraine aquifer complexes underlie much of the GR basin, which discharge groundwater into the GR in several locations, including the Grand River Discharge Reach (GRDR) between Cambridge and Brantford. We sampled groundwater and surface water over a period of 12 months at 11 locations in the GRDR and downstream to Lake Erie. We quantified the seasonal dynamics in the watershed's Si and P cycles, to test our hypothesis that regions of Si-rich groundwater discharge increase surface water Si:P ratios. Our analyses included both dissolved Si and reactive particulate Si, as well as total dissolved P. Our results indicate that groundwater Si:P ratios are lower than the corresponding surface water and that groundwater is a significant source of bioavailable P to surface water. Despite these observations, the watershed remains P-limited for the majority of the year, with localized periods of Si-limitation. *Keywords: Biogeochemistry, Silicon, Phosphorus, Grand River.*

MABREY, K.[1], GLYSHAW, P.[1], and ELGIN, A.K.[2], [1]CILER University of Michigan, G110 Dana 440 Church St, Ann Arbor, MI, 48109, USA; [2]NOAA Great Lakes Environmental Research Laboratory, 1431 Beach St., Muskegon, MI, 49441, USA. **Using the Fluoromarker Calcein to Assess Growth Rates of Quagga Mussels *in situ*.**

The quagga mussel (*Dreissena* r. bugensis) exerts a profound effect on the Lake Michigan food web. Understanding quagga mussel growth habits in situ will help us to better predict population growth and anticipate ecosystem effects. One technique used to mark mollusk species for growth experiments is exposure to the fluoromarker calcein. Studies on calcein are more common in marine conditions; less has been reported for freshwater species, let alone in natural environments. We conducted a field experiment at 45m in Lake Michigan to assess if calcein is an effective and noninvasive marking technique for quagga mussels. Mussels from two size groups were assigned to calcein or no calcein treatments, measured, then placed in replicate mesh cages attached to a tripod mooring platform 0.4m above the lakebed. We removed cages to remeasure mussels after 5 and 12 months. We captured fluorescent images using a dark box with a blue filter on the light source and a yellow filter on the camera. New shell growth beyond the calcein mark was visually delineated and measured using ImagePro Premier(v9.1) software. Preliminary results indicate that small and large quagga mussels respond differently to exposure to calcein. Studies using calcein will need to take these artifacts into account when measuring dreissenid mussel growth rates *Keywords: Invasive species, Growth rates, Dreissena, Fluoromarkers, Benthos.*

MACCOUX, M.J., SAUER, E.P., and WINTER, C.L., Milwaukee Metropolitan Sewerage District, 260 W. Seeboth St., Milwaukee, WI, 53204, USA. **Assessing the relationship between fDOM and DOC in Milwaukee area waterways.**

The Milwaukee Metropolitan Sewerage District began the use of a fluorescent dissolved organic matter (fDOM) sensor in October 2015 to assess the relationship with dissolved organic carbon (DOC) results run in the laboratory. Data were collected at river and creek sites that ranged from rural to highly urbanized areas. Measurements ranged from 1.8-75 mg/L for DOC and <0-494 QSE for fDOM. Raw fDOM data were used; specific corrections for temperature and turbidity are currently being developed by the manufacturer. Linear regression analysis was performed on all site data and a positive relationship was observed (adj. $r^2 = 0.7478$, $n = 1071$). Multiple regression found the interaction between fDOM and year significant, i.e., two slopes, one intercept (adj. $r^2 = 0.7893$), and the addition of precipitation further improved fit (adj. $r^2 = 0.8066$). This implies there may be interannual variability between the fDOM-DOC relationship, although 2015 data are only from October-December; more data needs to be collected to assess this. Further, seasonal, watershed, or site specific relationships may also improve model fit with continued data collection. Initial results appear promising for establishing a strong relationship between fDOM and DOC. *Keywords: Dissolved organic matter, Organic carbon, Water quality.*

MACRAE, M.L.[1], BRUNKE, R.[2], ENGLISH, M.C.[3], FERGUSON, G.[2], LAM, V.[1], LOZIER, T.[1], MCKAGUE, K.[2], O'HALLORAN, I.P.[4], PLACH, J.[1], and VAN ESBROECK, C.[1], [1]Department of Geography and Environmental Management, University of Waterloo, Waterloo, ON, CANADA; [2]Ontario Ministry of Agriculture, Food and Rural Affairs, Guelph, ON, CANADA; [3]Department of Geography and Environmental Studies, Wilfrid Laurier University, Waterloo, ON, CANADA; [4]School of Environmental Sciences, Ridgetown, ON, CANADA. **Importance of Climate Drivers and Land Management Practices on Runoff and Phosphorus Losses.**

The magnitude and speciation of agricultural phosphorus (P) loss and the partitioning of P losses between surface and subsurface pathways can vary with soil texture and slope, and land use/management practices. Runoff and P losses can also vary in time in response to season, event-based climatic drivers, antecedent moisture conditions and management practices. Little is known about supply and transport processes occurring during the winter period, despite the fact that this is when a substantial amount of P is lost. An improved understanding of the magnitude, speciation and flow paths of P loss occurring throughout an annual cycle, and, the climatic drivers of such processes, is needed to apply and evaluate appropriate Best Management Practices (BMPs) and improve modelling efforts. In Southern Ontario, Canada, we examined year-round, high-frequency dissolved and

particulate P losses over four years from six fields under corn-soybean-winter wheat rotation, where multiple BMPs are used (nutrient management, subsurface P placement, rotational conservation tillage and the periodic use of cover crops). Spatial and temporal patterns in edge of field P losses will be discussed, emphasizing water and P transport processes and highlighting the importance of individual and combined BMPs in mitigating P losses. *Keywords: Hydrologic budget, Phosphorus, Watersheds.*

MAHON, A.R. and RESH, C., Dept of Biology, Institute for Great Lakes Res. Central Michigan University, 3112 Biosciences Building, 1455 Calumet Ct., CMU, Mount Pleasant, MI, 48859, USA. **Population genomics of invasive species in the Great Lakes and beyond.**

Molecular tools have proven useful as delimiting tools for analyzing species in aquatic systems. From sampling individuals that could be physically captured to screening water samples for presence/absence of targeted species, these recently developed tools continue to provide information on which management decisions can be made. However, the field of molecular surveillance has moved beyond using single-species presence/absence methods such as standard PCR, qPCR, and ddPCR, etc. Newly developed high-throughput sequencing approaches allow for unprecedented amounts of data to be collected, enough so that population analyses of invasives have become possible. By analyzing whole genome scans of organisms for single nucleotide polymorphisms (SNPs), calculations of both population structure, effective population size, and number of breeding individuals can be calculated for species in aquatic ecosystems. In this study, we present population genomic data on two species of invasive fish, Ctenopharyngodon idella (grass carp) and Chana argus (northern snakehead) collected from their invaded ranges within North America. We will present current population structure of these two species in the basin and beyond. Additionally, our results calculate effective population sizes for *Keywords: Invasive species, Genetics, Monitoring.*

MAJARREIS, J.M.[1], BOEGMAN, L.[2], HIRIART-BAER, V.[3], HOWELL, E.T.[4], and SMITH, R.E.H.[1], [1]Department of Biology, University of Waterloo, 200 University Ave. W., Waterloo, ON, N2L3G1, CANADA; [2]Department of Civil Engineering, Queen's University, 99 University Ave, Kingston, ON, K7L 3N6, CANADA; [3]Environment and Climate Change Canada, 867 Lakeshore Rd, Burlington, ON, L7S 1A1, CANADA; [4]Ontario Ministry of the Environment and Climate Change, 125 Resources Rd., Toronto, ON, M9P 3V6, CANADA. **Water Quality Parameter Variability in Relation to Near-Bed Processes in the Lake Erie Nearshore.**

Water quality parameters (e.g. Chl a, NH4, and SRP concentration) can display vertical gradients even in the relatively shallow and well-mixed northern nearshore waters of East Basin Lake Erie. Dreissenid mussels are expected to be important agents of such gradients, which could be important to nuisance Cladophora growth. The current study investigated how physical processes influencing water column stability affected vertical patterns of Chl a, NH4, and SRP in an area with generally high Dreissenid mussel abundance. The water column was profiled for temperature, Chla, and conductivity and near-bed water velocity and temperature measurements were collected for calculation of dissipation and diffusivity at two 3m station and three 10m nearshore stations. NH4, and SRP concentration were measured from water column grab samples and near-bed passive samplers, and Chla from grab samples. Mussel abundance was estimated from quadrat sampling at the 10m stations. Stations displaying thermal stratification (Δ1°C/m) displayed vertical heterogeneity and directional gradients in water quality parameters, which appeared to be correlated with near-bed dissipation, diffusivity, and mussel abundance. Heterogeneity in Chla, NH4, and SRP in the water column and near-bed may be shaped by physical processes and Dreissenid mussels. *Keywords: Dreissena, Nutrients, Bottom currents.*

MALBURG, R.M.[1] and KREITINGER, J.P.[2], [1]U.S. Army Corps of Engineers Detroit District, 477 Michigan Avenue, Detroit, MI, 48226-2550, USA; [2]U.S. Army Corps of Engineers Engineer Research & Development Center Environmental Laboratory, 3909 Halls Ferry Road, Vicksburg, MS, 39180-6199, USA. **Predicting Toxicity of Hydrocarbons in Fish Tissues within the St Louis River Area of Concern.**

Predicting the toxicity of chemical mixtures present in an aquatic ecosystem is crucial to removing Beneficial Use Impairments (BUIs) impacting the ecosystem. The Target Lipid Model (TLM) can be used to assess the potential for chronic toxicity of petroleum-related chemicals measured in the water column to aquatic organisms. The TLM establishes a toxic unit (TU) comparing the measured concentration of a chemical to a species-specific critical effect concentration for that chemical. Summation of the TUs calculated predicts the potential narcotic toxicity of the hydrocarbons present in environmental media. The study presented applies the TLM to fifteen white sucker tissue samples collected by the US Fish and Wildlife Service from one of several targeted habitat restoration sites within the St Louis River Area of Concern (SLRAOC). The intent of this analysis is to determine whether the hydrocarbons measured in fish tissue collected within a SLRAOC targeted habitat restoration site may result in potential toxicity. The data developed and discussed provide additional support for evaluation of the fish and wildlife habitat and removal of the BUIs for the AOC. Additionally, application of the TLM within the SLRAOC establishes a methodology for similar analysis throughout the Great Lakes Region. *Keywords: St. Louis River AOC, Predicting toxicity, Fish tissue.*

MALINICH, T.D. and HÖÖK, T.O., Purdue University, 195 Marsteller St, West Lafayette, IN, 47906, USA. **Factors Leading to Plastic Expression of Morphological Variation of *Perca flavescens*.**

Intra-specific morphologic variation is a common feature among Great Lakes fishes. Specifically, several studies have documented differences among broadly defined groups, such as the morphological differences between two populations or between two habitats (e.g., littoral vs. pelagic zones, wetland vs. open lake). While such differences are interesting, their interpretation requires elucidation of contributors to variation in morphology such as the environmental drivers of plastic change in morphology, the consistency of morphological response to these drivers, and the temporal consistency of morphology particularly across seasonal changes. We approach these challenges using a series of experimental trials, comparing morphological differences between a control and common environmental drivers such as predation cues, habitat structure, and alternative diet options. Moreover, we examine the consistency of induced morphologies by sequentially exposing fish to different types of structural habitats. The results of our studies show fish morphology responded uniquely to each environmental driver. The differences between plastic responses in morphology affect the degree of variation within and among fish groups. *Keywords: Percids, Morphological Plasticity, Populations.*

MANDRAK, N.E., University of Toronto, 1265 Military Trail, Toronto, ON, M1C 1A4, CANADA. **History of Rapid Response to Aquatic Invasive Species in the Great Lakes.**

Upon the discovery of a new invasive species, there is a short window of opportunity to prevent its establishment or spread before it moves up the invasion curve to a point where eradication is no longer feasible. Of the 180+ aquatic invasive species in the Great Lakes, very few were subjected to a rapid response. Many invaded before such species were considered a concern or there was sufficient uncertainty in the potential impacts resulting in an unwillingness to take action. More recently, risk assessments that reduce this uncertainty have been conducted on many potential invaders of the Great Lakes, yet rapid response is still very rare. The few cases in which it has been attempted have been largely unsuccessful (e.g. Round Goby, Water Soldier, Water Chestnut) with some exceptions (e.g. Tench, Blue Crab). To be prepared for the next invaders (e.g. Asian carps, Tench), we must identify and rectify the impediments to responding to newly discovered invaders and prepare feasible action plans that can be carried out in a structured, timely manner. *Keywords: Invasive species, Management.*

MANDRAK, N.E.[1], NEEDS-HOWARTH, S.[2], WELAND, C.[3], LONGSTAFFE, F.J.[4], YAU, G.[4], and AUSTIN, S.[5], [1]University of Toronto Scarborough, Toronto, ON, CANADA; [2]Perca Zooarchaeological Research, Peterborough, ON, CANADA; [3]University of Guelph, Guelph, ON, CANADA; [4]The University of Western Ontario, London, ON, CANADA; [5]AMEC Foster Wheeler, Hamilton, ON, CANADA. **Archaeological Evidence Indicates Alewife (*Alosa pseudoharengus*) is Native to Lake Ontario.**

The origin of Alewife (*Alosa pseudoharengus*) in Lake Ontario has been widely debated. Alewife bones collected at an archaeological site adjacent to western Lake Ontario indicate that the species is native to Lake Ontario. Archaeological and radiocarbon analyses date the bones to be at least 500 years old, genetic analyses confirmed the species identity, and nitrogen isotope compositions were similar between archaeological and the present-day landlocked Alewife samples. Although it has had significant impacts on Great Lakes ecosystems since the late 1800s when it became abundant, Alewife was a symptom, not the cause, of human degradation of the Lake Ontario ecosystem. In recent years, Alewife populations have collapsed in the Great Lakes as a result of reduced pelagic productivity following the dreissenid mussel invasion. As it is native to Lake Ontario, Alewife should be managed as a component of a healthy Lake Ontario ecosystem. *Keywords: Alewife, Lake Ontario, Invasive species.*

MANGUS, A.E. and KARLL, K.C., Southeast Michigan Council of Governments, 1001 Woodward Ave.; Ste. 1400, Detroit, MI, 48226, USA. **Source Water Monitoring for Public Health, Infrastructure and Water Resource Goals.**

The Water Resources Plan for Southeast Michigan demonstrates a commitment to aligning water resource and infrastructure goals. A task force of experts facilitated by SEMCOG is drafting the plan to achieve local priorities, regional objectives and state water resource and infrastructure goals. The role of our drinking water systems is integral to creating a 21st Century Infrastructure System. Part of that system relies on monitoring source water entering water treatment plants to enable emergency response and contingency planning along the Lake Huron to Lake Erie international corridor. The Huron-to-Erie Real-time Drinking Water Protection Network , established in the mid-2000's, demonstrated a collaborative approach between local agencies to protect public health for over 4 million residents through a program not mandated at the state or federal levels. It included source water monitoring at the intakes and offered operators the ability to share information about water quality across the network. While technical and financial challenges have hampered continued participation, the local communities, partnering with SEMCOG, Wayne State University and the State of Michigan are reinvigorating the program. This presentation will highlight the history of the network and demonstrate the importance of collaboration. *Keywords: Water quality, Decision making, Policy making.*

MANNING, N.F.[1], BERTANI, I.[1], OBENOUR, D.R.[2], and SCAVIA, D.[1], [1]Water Center, Graham Sustainability Institute, University of Michigan, 625 E. Liberty St., Ann Arbor, MI, 48104, USA; [2]North Carolina State University, Campus Box 7908, Raleigh, NC, 27695, USA. **Influences of Anthropogenic and Climate-Related Drivers on the Spatio-Temporal Variability of HABs.**

Creating a long-term model that integrates drivers like climate and invasive species is critical to both advancing our understanding of HAB dynamics and developing reliable long-term forecasts to inform management. We enhanced our existing HAB model by updating the calibration dataset using geostatistical HAB estimates, and by testing the inclusion of additional predictors that are thought to influence bloom size, such as dreissenid mussel biomass, temperature, solar irradiance, and wind speed. We conducted a preliminary machine-learning analysis on existing HAB monitoring products to assess the role of multiple biophysical drivers, including tributary flow, wind forcing, water temperature, and solar irradiance, in influencing HAB size. Results from this work will inform the choice of climate-related predictors to be tested for inclusion in the model. Only variables that improve model performance (based on statistical variable selection) will be included in the model. We will test the model for predictive skill and robustness through cross validation. Overall, this research will advance our ability to measure HABs by synthesizing multiple datasets, to deeply understand the drivers and dynamics of HABs formation and dispersal, and to probabilistically predict both the duration and spatial distribution of future HABs occurrences. *Keywords: Lake Erie, Harmful algal blooms, Modeling.*

MARCACCIO, J.V. and CHOW-FRASER, P., McMaster University, 1280 Main Street West, Hamilton, ON, L8S 4K1, CANADA. **Pattern of Expansion of Phragmites Along Roadway Corridors in South Central Ontario: 2006 to 2015.**

One of the worst invasive plants in North America, *Phragmites australis* has aggressively invaded wetlands and wet areas throughout the Great Lakes basin. Highway corridors have facilitated their expansion because invasive Phragmites can tolerate stressful wet environments better than can native grass/sedge species. Based on the success of previous mapping efforts at a smaller scale, we are tracking changes in the distribution of invasive Phragmites in roadways throughout southwestern Ontario between 2006 and 2015 by building the McMaster Invasive Plant Database (MIPD). Images used to build the MIPD are spring-time (20-cm resolution) orthophotos acquired in 2006, 2010, and 2015. Using object-based image classification (eCognition), the accuracy of Phragmites classification exceeded 75%, and total image accuracy (six land cover classes) was over 70%. Our data show that roads with larger easements (e.g. 400-series highways) and those located in the southwest portion of the province have higher Phragmites densities. The MIPD is the first region-wide GIS inventory of Phragmites for the province of Ontario. By incorporating other geographic attributes associated with roadways into MIPD, we will inform managers of the effectiveness of control strategies and to identify areas that are most vulnerable to invasion. *Keywords: Biological invasions, Remote sensing, Phragmites australis.*

MARCACCIO, J.V. and CHOW-FRASER, P., McMaster University, 1280 Main Street, Hamilton, ON, L8S4K1, CANADA. **Evidence-based Strategies to Control Phragmites in Ontario's Highway Corridors using Glyphosate.**

Invasive *Phragmites australis* often use right-of-ways along roadsides to expand into wetlands and other wet areas throughout the Great Lakes region. Due to ecological and financial damage, management of this invasive plant has become a pressing issue for municipal and provincial transportation managers as they seek to curb its expansion. Here, we determine the effectiveness of these treatment efforts throughout roadways managed by the Ontario Ministry of Transportation (MTO). All roads treated by MTO in their West region (approx. Windsor to Norfolk County to Bruce Peninsula) prior to 2014 were chosen for this analysis. To determine if treatment with glyphosate (2%) has been effective, we use the McMaster Invasive Plant Database (MIPD) that contains the distribution of Phragmites in 2010 and 2015. Using change-detection techniques in GIS, we have determined which of the Phragmites stands has grown (i.e. ineffective treatment), receded or disappeared from the landscape (i.e. effective treatment). Eradiation of Phragmites is possible on arterial roads where small patches exist, but appear to be less effective on multi-lane highway where newly emerging stands and large colonies outside of road easements can re-inoculate infected areas. Our data suggest that control is temporary and must be accompanied by repeat treatment. *Keywords: Glyphosate, Phragmites australis, Remediation.*

MARINO, J.A.[1], PEACOR, S.D.[2], BUNNELL, D.B.[3], VANDERPLOEG, H.A.[4], POTHOVEN, S.A.[5], ELGIN, A.K.[5], and IONIDES, E.L.[6], [1]Department of Biology, Bradley University, 1501 W. Bradley Ave., Peoria, IL, 61625, USA; [2]Department of Fisheries and Wildlife, Michigan State University, 480 Wilson Road, Room 13, East Lansing, MI, 48824, USA; [3]USGS Great Lakes Science Center, 1451 Green Rd, Ann Arbor, MI, 48105, USA; [4]NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Rd., Annn Arbor, MI, 48108, USA; [5]NOAA Great Lakes Environmental Research Laboratory, 1431 Beach St, Muskegon, MI, 49441, USA; [6]Department of Statistics, University of Michigan, 1085 S. University, Ann Arbor, MI, 48109, USA. **Fitting models to field time series data to quantify *Bythotrephes* effects in Lake Michigan.**

Quantifying the effects of invasive species on population dynamics constitutes a key goal of ecological research. Survey data taken over multiple years can play a key role in elucidating processes. However, the nonlinear stochastic behavior intrinsic to ecological systems and limitations in the data such as measurement error and irregular sampling intervals may impair assessment of predator effects. A new, likelihood-based method to fit dynamic models to time series data, iterated filtering, addresses these challenges. We employed this method to assess effects of an invasive predatory zooplankter, *Bythotrephes longimanus*, on a key prey species, *Daphnia mendotae*. We developed models of *Bythotrephes-Daphnia* interactions and fit them to offshore seasonal time series from Lake Michigan (1994-2012). Results indicate substantial, seasonally varying *Bythotrephes* effects on Daphnia growth rates, with a 91% reduction at *Bythotrephes* maximum. We are also exploring whether observed effects are most consistent with consumptive or nonconsumptive effects; our recent results suggest the latter may contribute more strongly, in line with other experimental and observational work. Our findings thus demonstrate how dynamic modeling can complement other methods to provide insights into invasive species ecology.
Keywords: Invasive species, Modeling, Zooplankton.

<u>MARSDEN, J.E.</u>[1], DINGLEDINE, N.[2], and ADAMS, J.[3], [1]University of Vermont, 81 Carrigan Dr, Burlington, VT, 04505, USA; [2]DLZ Michigan, 1425 Keystone Ave, Lansing, MI, 48911, USA; [3]Michigan Dept of Environmental Quality, 2100 West M-32, Gaylord, MI, 49735, USA. **Long-Term Assessment of the Physical Integrity and Biotic Colonization of Artificial Reefs.**

Artificial reefs are widely used to restore damaged habitat, particularly spawning habitat. However, reefs are often constructed without clear objectives or a long-term assessment plan to evaluate changes in reef characteristics. To mitigate for degradation of lake trout spawning habitat in Thunder Bay, Lake Huron, we constructed 29 cobble reefs in 2010-11. Reef design incorporated height, orientation, and size as replicated factors. In addition to assessment of lake trout spawning activity and fry production, we evaluated the biotic and abiotic changes in the reefs over 5 years post-construction. Each reef was mapped annually by side-scan sonar to examine changes in the physical structure, such as slumping. Divers photographed a subset of the reefs each year, and sampled substrate to quantify benthic macroinvertebrates, including zebra mussels. Algal colonization and round gobies were evaluated qualitatively. Temperature, dissolved oxygen, and sediment accumulation were measured over the winter at the center and base of two reefs each year. Little physical

change or sedimentation occurred. Lake trout spawning activity, presence of other fish species, and colonization by algae and macroinvertebrates increased throughout the monitoring period, indicating that the reefs have long-term value for a diversity of species. *Keywords: Remediation, Habitats, Fisheries.*

MARSHALL, C.C., CONNOLLY, J.K., WATKINS, J.M., and RUDSTAM, L.G., Cornell University, Department of Natural Resources, 110 Fernow Hall, Ithaca, NY, 14853, USA. ***Cercopagis* Predation Impact upon Rotifer Communities in Lakes Ontario and Erie.**

Rotifers are typically preyed upon by larger zooplankton including copepods, cladocerans, and larger rotifers. Previous studies have hypothesized that the introduction of the predatory cladoceran *Cercopagis* has led to a decrease of total rotifer abundance. For example, Makarewicz suggested that both *Keratella cochlearis* and *Polyarthra spp*. abundances significantly decreased with the introduction of *Cercopagis* to Lake Ontario. We focus on rotifer communities in Lake Ontario and Eastern Lake Erie in the summers of 2012-2014 to evaluate *Cercopagis* impacts. *Cercopagis* densities varied from low values in Lake Erie (around 4 ind/m^3 in 2012, undetectable in 2013 and 2014), whereas average summer densities in Lake Ontario increased from 72/m^3 in 2012, to 164/m^3 in 2013 and 397/m^3 in 2014. The comparisons among these two lakes and three years therefore allow us to investigate the relationship between *Cercopagis* and the rotifer community structure. We hypothesize that non-loricated species and species with smaller spines are disproportionately affected by high *Cercopagis* densities. *Bythotrephes*, *Limnocalanus macrurus*, and cyclopoid copepod populations are also examined in relation to the rotifer community structure. *Keywords: Cercopagis pengoi, Rotifers, Zooplankton, Predation.*

MARSHALL, N.T.[1], KLYMUS, K.E.[2], and STEPIEN, C.A.[3], [1]University of Toledo & NOAA PMEL, Dept. of Environmental Sciences, Toledo, OH, 43606, USA; [2]USGS, Columbia Environmental Research Center, Columbia, MO, 65201, USA; [3]NOAA PMEL, 7600 Sand Point Way NE, Seattle, WA, 98115, USA. **Evaluating Genetic Diversity of Dreissenid Mussel Communities with High-Throughput Sequencing.**

The Great Lakes are one of the most invaded aquatic habitats, with 186+ invasive species, including the notorious dreissenid mussels. Environmental (e)DNA (genetic material shed from organisms via waste, mucus, filter feeding) is a powerful technique to assess an invader's presence. However, most assays just reveal single species' presence/absence, lacking information about relative abundance and genetic diversity. Here a diagnostic genetic assay evaluates the relative proportions of dreissenid taxa and genotypes within invasive communities. Primers were developed for a diagnostic region of the COI mtDNA gene that reveals haplotypic information. Accuracy was evaluated with i) Illumina sequencing of a series of mock communities containing known, varying concentrations of DNA from a mix of quagga and zebra mussel haplotypes, and ii) aquaria experiments with varying proportions of mixed species/haplotype composition. Results show that observed relative abundances are highly correlated with expected relative abundances, confirming the assay's performance. The assay then was tested with iii) field water and plankton samples, in reference to traditional sampling. Findings will be useful in addressing foundational ecological and population genetic questions, as well as informing agencies about population trends of invasive taxa. *Keywords: Genetics, Zebra mussel, Invasive species, Quagga mussel, Dreissena, EDNA.*

MARTIN, J.F.[1], ALOYSIUS, N.[1], HOWARD, G.[2], KALCIC, M.M.[1], WILSON, R.[1], MUENICH, R.L.[3], ROE, B.[1], ZHANG, W.[4], LIU, H.[1], SCAVIA, D.[3], and IRWIN, E.[1], [1]Ohio State University, 590 Woody Haze, Columbus, OH, 43210, USA; [2]East Carolina University, Greenville, NC, 27858, USA; [3]University of Michigan, Ann Arbor, MI, 48109, USA; [4]Iowa State University, Ames, IA, 50011, USA. **Projection and Adoption of Management Plans to Reduce Lake Erie's Harmful Algal Blooms.**

In 2016, the United States and Canada formally agreed to reduce phosphorus inputs to Lake Erie by 40% to reduce the severity of Harmful Algal Blooms (HABs). Our research has compared the amount and types of practices needed for this reduction to the current and projected levels of adoption. Economic resources required to implement necessary management changes are compared with the general public's willingness to pay to improve Lake Erie water quality. Multiple models of the Maumee watershed identified management plans and adoption rates needed to reach the reduction targets. Current adoption is below these levels, but future projections based on farmer surveys show these levels are possible. Public support is necessary to generate the funding to support cost sharing and other programs aimed at increasing adoption of recommended practices. Comparing results from willingness-to-pay surveys of the general public with the estimated need for these management plans shows a gap in resources to support these levels of adoption. These results show that accelerated adoption of management plans is needed compared to past adoption rates, but that these rates are possible based on likely adoption rates. Accelerated rates of voluntary adoption may be stimulated by increasing the perceived efficacy of the practices. *Keywords: Ecosystem modeling, Harmful algal blooms, Watersheds.*

MARTIN, R.M.[1], STEENHAUER, L.M.[2], MONIRUZZAMAN, M.[1], STOUGH, J.M.A.[1], KOSTER, A.J.[2], BRUSSAARD, C.P.D.[2], and WILHELM, S.W.[1], [1]University of Tennessee, Knoxville, TN, USA; [2]Royal Netherlands Institute for Sea Research and Utrecht University,

Texel, NETHERLANDS. **Genome sequence of Cylindrospermopsis raciborskii Virus and host: from test tube to invasion ecology.**

The presence of viruses infecting particular microorganisms has historically been used as a marker for the presence of the viral host. More recently, the study of virus themselves has influenced thoughts on ecosystem scale ecology. We have sequenced the genome of a strain of *Cylindrospermopsis raciborskii* and an infecting phage, both isolated from the Reeuwijkse Lakes in The Netherlands. Morphology deduced from transmission electron microscopy demonstrates this cyanophage is a member of the *Siphoviridae family*, with an icosahedral capsule (diameter of ~60 nm) and a non-contractile tail of ~600 nm. The virus's genome was assembled into four contigs that, including a duplicated region, result in an estimated genome size of ~105 kb with ~100 predicted ORFs. Work is ongoing to close and annotate the genome. In parallel, sequences from principal marker genes are being used to query available metagenomic and transcriptomic data sets to determine the prevalence and distribution of similar viruses in an effort to understand the potential ecological role of this phage in the dynamics of *Cylindrospermopsis*, including its invasion of the Laurentian Great Lakes. *Keywords: Cylindrospermopsis, Virus, Genomics.*

MARTINEZ-MARTINEZ, E.[1], NEJADHASHEMI, A.P.[1], WOZNICKI, S.A.[1], ADHIKARI, U.[1], and GIRI, S.[1], [1]Department of Biosystems and Agricultural Engineering, 524 South Shaw Lane, East Lansing, MI, 48824, USA; [2]Department of Plant, Soil and Microbial Sciences, 1066 Bogue Street, East Lansing, MI, 48824, USA. **Evaluating the wetland restoration scenarios for watershed-scale sediment reduction.**

Over half of the wetlands in the US has been lost since European settlement. With the realization of wetland values, there is an increasing interest in wetland restoration to regain the lost functions, but their placement in watersheds for optimizing water quality benefits has not yet fully understood. To fill the knowledge gap, this study coupled the Soil Water Assessment Tool (SWAT) and System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN) models to evaluate the impacts of wetland restoration on sediment reduction. Four wetland sizes (0.40, 0.81, 2, and 4 ha) were evaluated one-at-a-time within the River Raisin watershed and environmental and economic issues were considered at the subwatershed as well as watershed level for ranking and placement of wetlands. The result showed that the wetlands restored 150-200 stream km from the outlet outperformed other wetlands. Additionally, wetlands placed on first order streams performed better in sediment reduction at the subwatershed level but wetlands on fourth order streams performed better at the watershed level. Both environmentally and economically, smaller wetlands (0.4 ha) were found to be the most suitable for restoration. *Keywords: Wetlands, Wetland restoration, Sediments, SWAT, Watersheds, SUSTAIN.*

MARTZ, M.A.[1], DOMSKE, H.M.[2], MCCARTNEY, A.X.[1], and EVANS, H.[3], [1]PA Sea Grant, Pennsylvania State University, 301 Peninsula Drive, Suite 3, Erie, PA, 16505, USA; [2]New York Sea Grant-Cornell University, 229 Jarvis Hall, SUNY at Buffalo, Buffalo, NY, 14260-4400, USA; [3]Fort LeBoeuf School District, 34 East 9th Street, Waterford, PA, 16411, USA. **Building Support for Microplastic Research Through Education and Outreach.**

This presentation will highlight examples of Best Practices that have supported plastics research in the Great Lakes. Sea Grant educators from Pennsylvania and New York will discuss successful collaborative efforts that have benefited researchers and stakeholders alike. Highlighted activities include a Great Lakes regional conference, Newspaper in Education publications, school programs and public presentations where researchers and Sea Grant staff have worked together to enhance their work, identify research gaps and develop support for research funding. *Keywords: Environmental contaminants, Microplastics, Outreach.*

MASON, L.[1], SAMPSON, K.[2], DUGGER, A.[2], GOCHIS, D.[2], RISENG, C.[1], and GRONEWOLD, A.D.[3], [1]University of Michigan, Institute for Fisheries Research, Ann Arbor, MI, USA; [2]NCAR, Boulder, CO, USA; [3]NOAA (GLERL), Ann Arbor, MI, USA; [4]University of Michigan (Department of Civil and Environmental Engineering), Ann Arbor, MI, USA. **Development of a new geospatial hydrofabric to support advanced hydrological modeling.**

As the state-of-the-art in hydrological models advances across North America and around the world, so does the need to develop suitable hydrologic and hydrographic data for supporting those models. Addressing that need can be challenging depending on regional variations in data availability, and in representation of regionally-significant geographic features (including, for example, lakes, terrain, and coastlines). Blending data across jurisdictional boundaries represents yet another challenge, one that is particularly relevant to the Laurentian Great Lakes. More specifically, hydrological models across the Great Lakes basin require hydrography data that explicitly reconcile the boundary of the North American Great Lakes and the channels that connect them (including the St. Marys, St. Clair, Detroit, and Niagara Rivers). Here, we present a new hydrofabric that supports implementation of the National Water Model (NWM) across the entire Great Lakes domain. By facilitating regional implementation of the NWM, the new hydrography data serves as a critical stepping stone toward improved hydrological data and forecasting for the Great Lakes basin, as well as improved model-based water management decisions. *Keywords: Hydrologic cycle, Modeling, Watersheds.*

MATA, T.M.[1], SOWA, S.P.[1], DORAN, P.J.[1], and COLE, S.J.[2], [1]The Nature Conservancy, 101 East Grand River Avenue, Lansing, MI, 48906, USA; [2]Great Lakes Commission, 2805

South Industrial Highway, Ste. 100, Ann Arbor, MI, 48104, USA. **Using Blue Accounting to Track Environmental, Social and Economic Progress in the Great Lakes Basin.**

The Great Lakes are poised for huge economic investments in infrastructure and restoration. Blue Accounting provides a framework and support for setting shared environmental, social, and economic goals for Great Lakes water resources and tracking the impact of investments and management decisions on progress toward achieving those goals. With several pilot projects underway focusing on environmental health, the initiative team, co-led by the Great Lakes Commission and The Nature Conservancy, is exploring opportunities to track investments in the "blue economy" of the Great Lakes. The *Governors' and Premiers' Strategy for the Great Lakes and St. Lawrence River Maritime Transportation System*, which seeks to double maritime transport while decreasing environmental impact, offers a timely pilot project opportunity to expand the current Blue Accounting initiative in partnership with the private sector. Blue Accounting can facilitate the development of metrics toward this goal and establish baselines against which Great Lakes leaders can track progress and evaluate the impact of policies and investments. To be successful, Blue Accounting hopes to engage the research community in identifying research and data gaps that are critical to understanding the interrelated economic and ecological system.
Keywords: Economic impact, Metrics, Ecosystem health.

MAY, C.A., The Nature Conservancy, Lansing, MI, 48906, USA. **Erie Marsh Preserve: Restoration of a Diked Coastal Wetland.**

Erie Marsh Preserve in western Lake Erie includes 945 acres of Great Lakes coastal marsh within a system of dikes constructed during the 1950s. This project will ultimately restore and enhance the 945 acres in 10 independent management units through the construction or improvement of dikes, distribution canals, water control structures, and the installation of a new water supply system and fish passage structure. In 2012, the fish passage structure was completed, restoring a hydrologic and physical connection between Lake Erie and the managed dike portion of Erie Marsh Preserve following 60 years of separation. The diked wetlands are critically important for spring, fall, and winter staging, feeding, and resting of waterfowl and other wildlife, as well as home to unique plants. The improved infrastructure will provide capacity for long-term, adaptive management of a high-quality coastal wetland complex and control of invasive Phragmites. Pre- and post-restoration monitoring includes water quality, fish, birds, herpetofauna, and vegetation; we have documented increased abundance and diversity of fish, native vegetation, and herpetofauna. The presentation will include details of the site design and operation, climate-wise features, pre-restoration monitoring results, and preliminary results from post-restoration monitoring.
Keywords: Diked wetland, Lake Erie, Monitoring, Coastal wetlands, Climate change.

MAYERFELD, P., Turner Designs, 1995 N. 1st street, San Jose, CA, 95112, USA. **Rapid Compliance Monitoring using Indicative Tools.**

There is an ongoing question as to how ships will show they are in compliance with regulations when they pull into ports as well as how port state control might check this. Making a direct measurement of compliance can be a long process requiring skilled scientists and resulting in costly delays. Several companies have developed rapid compliance tools which make indicative measurements based on well-established scientific methods. The question is - what is being done in the maritime industry to show these indicative measurements are truly a good indication of compliance with the ballast water regulations. This presentation will present why people are targeting the 10-50um sample size for these indicative measurements, the types of data presented by indicative tools, an overview of the various instruments being developed, and then most importantly, what organizations are validating compliance monitoring and what is the current status of their validations. In addition, some organizations who have already adopted using compliance monitoring in their processes and how they are using it will be included. *Keywords: Ballast, Rapid compliance monitoring, Indicative monitoring.*

MCCANN, E.L.[1], JOHNSON, N.S.[2], and PANGLE, K.L.[1], [1]Central Michigan University, Mount Pleasant, MI, 48858, USA; [2]USGS, Hammond Bay Biological Station, Millersburg, MI, 49759, USA. **Long-term Temperature Changes in Clustered Streams Correspond to Shifts in Invasive Fish Migration.**

Climate change affects many ecological and biological processes in aquatic systems worldwide. However, direct evidence showing how long-term stream temperature changes influence invasive fish spawning migration timing are lacking. By investigating historic trapping records of invasive sea lamprey (*Petromyzon marinus*) throughout the Laurentian Great Lakes basin, we found that spawning migration timing was highly correlated with stream temperatures. Furthermore, we found that long-term water temperature trends varied strongly among streams. Many exceeded a critical thermal threshold (i.e. 15°C) and experienced peak spawning migration up to 30 days earlier since the 1980s, whereas others were relatively unchanged. One stream even experienced significant cooling and a corresponding shift to later peak migration. Warming streams were clusterted on the leeward side of the Great Lakes where lake effect snow occurs during the winter. These findings demonstrate the high-degree of variability to which river ecosystems have responded to change in climate and represent the first observation linking changing stream temperatures to migration timing shifts of an invasive fish. The ecological ramifications of earlier migration may have negative implications for sea lamprey control and may be occurring in other invasive fishes worldwide. *Keywords: Climate change, Great Lakes basin, Fish migration, Sea lamprey, Invasive species.*

MCCARTHY, M.J.[1], NEWELL, S.E.[1], CHAFFIN, J.D.[3], MYERS, J.A.[1], BOEDECKER, A.R.[1], ZHANG, L.[4], XU, H.[4], ZHU, G.W.[4], and GARDNER, W.S.[2], [1]Wright State University, Dayton, OH, USA; [2]U Texas Mar Sci Inst, Port Aransas, TX, USA; [3]Stone Laboratory, Put-in-Bay, OH, USA; [4]Nanjing Inst Geog Limnol, Nanjing, CHINA. **Microbial nitrogen sinks in large lake sediments as an ecosystem service.**

Relative to phosphorus, nitrogen (N) is understudied (and generally unmanaged) in freshwater systems, and significant knowledge gaps remain in our understanding of the role of N in causing eutrophication and cyanobacteria blooms. Modern cyanobacteria blooms are often dominated by non-N-fixing taxa, which require combined N for biomass and toxin production. As such, the amount and fate of N loads into eutrophic systems is of critical importance. Sources and sink terms in N budgets are therefore important to quantify. Nitrogen sinks represent an "ecosystem service" in that N otherwise available for primary production is removed from the system. The value of these services, in monetary terms, may help justify inclusion of N in eutrophication management and ecosystem modeling efforts, neither of which currently include N at a sufficient level. Microbial N sinks in aquatic sediments include denitrification, the step-wise reduction of nitrate to dinitrogen gases (including nitrous oxide), and anaerobic ammonium oxidation (anammox), the chemolithoautotrophic conversion of ammonium and nitrite to dinitrogen gas. We are evaluating these processes in large lakes Erie and Taihu, and we will compare these rates to N loading estimates to estimate the monetary value of the ecosystem services they provide. *Keywords: Sediments, Anammox, Cyanophyta, Denitrification, Eutrophication, Large lakes.*

MCCLURE, A.P.[1], CAMPBELL, C.[1], and VERHAMME, E.M.[2], [1]City of Toledo Water Department, 3040 York St., Toledo, OH, 43605, USA; [2]LimnoTech, 501 Avis Dr., Ann Arbor, MI, 48103, USA. **Ongoing Research and HABs Strategy for City of Toledo Water Utilities.**

The City of Toledo Department of Public Utilities Division of Water Treatment is proud of its efforts to cooperate with researchers to advance the understanding of the western basin of Lake Erie. The division uses research data for process control and maintains open lines of communications with researchers to stay ahead of problems to help assure continued reliable provision of drinking water to northwest Ohio. This presentation will discuss research, past, present and future, and how results of this research have been implemented over time. Research and implementation to be discussed will range from zebra mussels to microcystin. *Keywords: Drinking water, Harmful algal blooms, Lake Erie.*

MCCRIMMON, C., ZHAO, J., LEON, L., and YERUBANDI, R., Environment Canada, Burlington, On, CANADA. **Honey Harbour and Nottawasaga River Plume Modelling, Lake Simcoe / Georgian Bay Study.**

As part of the Environment and Climate Change Canada departmental priority related contributing to the understanding and rehabilitation of Georgian Bay near-shore, analysis and modelling of the hydrodynamics of Georgian Bay and Nottawasaga River plume and hydrodynamics and water quality for Honey Harbour and Tadenac Bay were carried out. ELCOM/CAEDYM (ELCD) 3D modelling showed the river plume was distinct and advected along the north / north-west along the Georgian Bay shoreline, as far as Port Severn. At Honey Harbour, the thermal structure, circulation, dispersion and water quality, were studied using 2D and 3D (ELCD) models. The inflow from Baxter River has a strong influence on the south basin of Honey Harbour; exchange with Georgian Bay is also important; and there is a release of nutrients from the sediments, during summer stratification bottom anoxia, which can become a source for phytoplankton growth. Significant impact from local septic system loads was not identified. Tadenac Bay, which has only 1 lodge, was used to compare and contrast with Honey Harbour. Tadenac Bay is influenced by exchange with Georgian Bay similar to Honey Harbour, and possibly to an upstream river, but sparser data did not allow for any conclusions on sediment release of nutrients or other sources. *Keywords: Modeling, Nutrients, Hydrodynamics.*

MCGOLDRICK, D.J.[1] and MURPHY, E.W.[2], [1]Environment and Climate Change Canada, 1Water Science and Technology Directorate, 867 Lakeshore Rd., Burlington, ON, L7T 3M3, CANADA; [2]US Environmental Protection Agency, Great Lakes National Program Office, 77 W. Jackson Blvd., Chicago, IL, 60604, USA. **Mean Deviation Ratio: A Novel Approach to assessing multiple Chemicals in Great Lakes Whole Fish.**

The Mean Deviation Ratio (MDR) is a novel approach for assessing multiple chemical stressors in Great Lakes Whole Fish that is being explored in Federal reporting as a way to assess and communicate the overall status and condition of fish with respect to chemicals of concern to a non-scientific audience. The MDR represents the average magnitude of deviation from target conditions for multiple contaminants of interest. The resulting values are unit-less measures of distance from the desired condition which are equivalent for all contaminants regardless of their unit of measure calculated on an annual basis. The MDR is a ratio that will never reach zero and is bounded by infinity where a value of 1 occurs when, on average, the concentrations of the contaminants included in the calculation are at their guidelines. Values between 1 and zero indicate that concentrations are below guideline, values greater than 1 indicate that concentrations are above guidelines. MDRs were generated for each of the Great Lakes and basin-wide using the long-term

monitoring datasets of ECCC and the USEPA for contaminants in fish to demonstrate this concept as a communication tool. *Keywords: Fish, Environmental contaminants, Outreach.*

MCGUIRE, K. and JUDD, K., Eastern Michigan University, Department of Biology, 441 Mark Jefferson Science Complex, Ypsilanti, MI, 48197, USA. **Salt retention in wetland sediments: a mesocosm experiment.**

Application of road salt (NaCl) can have negative consequences on aquatic systems. Wetlands may intercept road salt run-off before it reaches aquatic ecosystems. However, little is known about how salt moves through wetland soils. To address this question, soil cores collected from three wetland sites in southeast Michigan within the Huron River Watershed were flushed with one of three concentrations of NaCl (0, 2.5, and 5.0 g L^{-1}) three times over nine days, followed by three flushes over nine days of salt-free water. We measured salt retention by analyzing Cl- in effluent and the amount of salt that accumulated in soils. Even after flushing with salt-free water, soils retained 7-20% (0.13 - 0.35 mg Cl g^{-1} soil) of the medium level salt treatment and 5-15% (0.20 - 0.55 mg Cl g^{-1} soil) of the high salt treatment, even after three flushes with salt-free water, with high carbon soils retaining the most salt. These findings suggest that a physical, chemical, or biological retention mechanism in wetland soils may affect the movement of salt through wetlands to streams and coastal zones. *Keywords: Wetlands, Road salt, Pollutants, Retention.*

MCGUIRE, M.P., University of Florida/Florida Sea Grant Extension, 150 Sawgrass Road, Bunnell, FL, 32110, USA. **Florida Microplastic Awareness Project: A Citizen Science Initiative.**

Plastic pollution in the oceans is an increasing problem. Microplastics (plastic pieces smaller than 5 mm in size) are being found in fish and invertebrates. The Florida Microplastic Awareness Project aims to raise awareness about microplastics, in part by having citizen scientists collect and analyze coastal water samples for the presence of microplastics. Volunteers and others in the community are asked to reduce their consumption/disposal of plastics. Sixteen coordinators around the state give presentations about microplastics to potential volunteers, then conduct hands-on trainings to show water collection and analysis techniques. Volunteers are asked to collect at least four samples during the year, filter them and observe the filters to count the number of pieces of plastic present. Data are used to populate a Google Map. People are asked to take a pledge to reduce their plastic waste. Results: Data from over 800 water samples show that 88% contain at least one plastic item. On average, there are seven pieces of plastic in a liter of coastal water. 82% of the plastic items are fibers/filaments. On average, people are pledging to make 3.5 of the suggested eight behavior changes to reduce plastic waste. In follow-up

surveys, people are reporting having made an average of three behavior changes.
Keywords: Pollutants, Microplastics, Citizen science.

MCKAY, R.M.L.[1], BULLERJAHN, G.S.[1], BERNAT, G.[2], PRASIL, O.[2], VÖRÖS, L.[3], PALFFY, K.[3], TUGYI, N.[3], and SOMOGYI, B.[3], [1]Bowling Green State University, Dept. Biol. Sci., Bowling Green, OH, 43403, USA; [2]Center Algatech, Institute of Microbiology, Trebon, 379 81, CZECH REPUBLIC; [3]Balaton Limnological Institute, Tihany, HUNGARY. **Community Dynamics and Function of Algae and Bacteria During Winter in Central European Great Lakes.**

Abundant phytoplankton and bacteria were identified by high-throughput 16S rRNA tag Illumina sequencing of samples from water- and ice phases collected during winter at two central European Great Lakes, Balaton and Fertö (Neusiedlersee). Bacterial reads at all sites were dominated (>85%) by Bacteroidetes and Proteobacteria. Amongst phototrophs, both phytoplankton and cyanobacteria were represented with hundreds of sequence reads per sample, a finding corroborated by microscopy and flow cytometry. In particular, both water and ice from Fertö contained high contributions from cyanobacteria. Five percent of total reads in water at Fertö were dominated by a single operational taxonomic unit of the cyanobacterium *Calothrix* sp. which was largely absent from ice. Fluorescence emission spectra obtained at 77K confirmed the presence of intact cyanobacteria in Fertö water and ice. Photosynthetic characterization of phototrophs resident in water and ice analyzed by variable chlorophyll a fluorescence and assay of acid-stable photosynthetic $H^{14}CO_3^-$ incorporation showed that communities from both phases were photosynthetically active, thus adding to growing recognition of ice-covered lakes as viable habitat for phototrophs.
Keywords: Phytoplankton, Cyanobacteria, Algae, Photosynthesis.

MCKAY, R.M.L.[1], TUTTLE, T.A.[1], BULLERJAHN, G.S.[1], REITZ, L.[1], MCDOWELL, A.[2], JOHNSON, L.T.[3], and DAVIS, T.W.[4], [1]Bowling Green State University, Bowling Green, OH, 43403, USA; [2]City of Defiance, Water Division, Defiance, OH, 43512, USA; [3]Heidelberg University, National Center for Water Quality Research, Tiffin, OH, 44883, USA; [4]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, 48108, USA. **An Early Onset and Highly Toxic Cyanobacterial Bloom in the Maumee River (OH).**

In May 2016, a cyanobacterial harmful algal bloom (cHAB) was detected in the Maumee River at Defiance, OH. Testing on 31 May identified *Planktothrix agardhii* as the dominant cyanobacterium with cell abundance exceeding 1.7×10^9 cells/L and total microcystins reaching 19 µg/L, a level over 10-fold higher than the revised U.S. EPA national health advisory levels for drinking water exposure to adults. Low discharge and no precipitation through the latter half of May coincided with an 80% decline in river turbidity that likely favored bloom formation. The bloom persisted through 5 June with microcystins exceeding 22 µg/L downriver at Napoleon, OH and with microcystins detectable (>3.5 µg/L) in early June at the mouth of the Maumee River. By 6 June, the River had returned to its muddy character following a rain event and sampling on 7 June detected only low levels of toxin (<0.6 µg/L) at public water systems in Defiance and Napoleon. The elevated toxicity of this early onset bloom was without precedent for the Maumee River. Whereas *Planktothrix* is common in lotic environments, and has been previously detected in the Maumee, blooms are uncommon. This toxic and early cHAB provided a rare opportunity to glean insights into factors that promote bloom development and toxicity in lotic environments. *Keywords: Harmful algal blooms, Maumee River, Cyanophyta.*

MCKEE, G.[1], BERGLUND, E.K.[2], CHIODO, A.[2], FISCHER, F.[2], DUNLOP, E.[3], PRATT, T.[4], and RENNIE, M.D.[1], [1]Lakehead University, Department of Biology, Thunder Bay, ON, CANADA; [2]Ontario Ministry of Natural Resources and Forestry, 2Upper Great Lakes Management Unit, Thunder Bay, ON, CANADA; [3]Ontario Ministry of Natural Resources and Forestry, 3Aquatic Research and Monitoring Section, Thunder Bay, ON, CANADA; [4]Fisheries and Oceans Canada, Great Lakes Laboratory for Fisheries and Aquatic Science, Sault Ste. Marie, ON, CANADA. **Diversity in Movement Ecology among Walleye in Black Bay, Lake Superior.**

Once the source of the largest Walleye fishery on Lake Superior, A large area of Black Bay is now a sanctuary from commercial and recreational harvest to help restore Walleye in this region. However, the degree to which Black Bay represents a discrete population independent of the influence of outside regions is unknown. Recent work elsewhere on the Great Lakes has documented long-range migration in Walleye, hundreds of kilometers from their tagging location on spawning grounds. In order to evaluate the potential for long-range migration in Black Bay, we monitored the movement of Walleye implanted in the spring of 2016 with acoustic transmitters via their detection on an acoustic telemetry array. While a number of fish remained in Black Bay during the season, we found that almost 30% of tagged fish left Black Bay entirely during the summer of 2016, the majority of which migrated towards (and ultimately returned from) the Sibley Peninsula. Our results indicate possible evidence for long-range migration out of the bay. Future work will be focused on characterizing the westward extent of migrations, and the potential for alternative life history strategies between migrants and residents. *Keywords: Acoustics, Fish behavior, Migrations.*

MCKENNA, J. and KOCOVSKY, P.M., US Geological Survey, 6100 Columbus Ave, Sandusky, OH, 44870, USA. **A Comparison of Morphology of Silver Chub from Lake Erie and the Mississippi River.**

Silver Chub (Cyprinidae: Macrhybopsis storeriana) is the largest native cyprinid in the Great Lakes and exists only in Lake Erie, where it is listed as endangered under COSEWIC. Silver Chub core range is the large rivers of the Mississippi River basin, but separated populations also exist in the Alabama, Assiniboine, Brazos (possibly extirpated), Pascagoula, Pearl, Red (north), and Tombigbee Rivers. Disconnected riverine populations likely became established via stream capture events or flooding of headwater reaches. The Lake Erie population was separated from the Mississippi River basin between 14,000 and 11,000 ya as drainage patterns changed following Wisconsinan glaciation. Due to this isolation, different selective pressures in riverine and lake environments may have led to differences in morphology. We tested for differences in whole-body morphology of Silver Chub from digital images of fish from a Mississippi River pool and western Lake Erie using geometric morphometric methods (Procrustes, relative warp, and PCA) in the geomorph package in R. Results of this pilot study compliment ongoing genetic analyses, will inform whether a broader comparison is warranted, and will support efforts to develop a recovery plan for Silver Chub in Lake Erie. *Keywords: Biodiversity, Systematics, Lake Erie.*

MCKINNEY, P.J.[1], AUSTIN, J.A.[2], and FAI, G.[2], [1]US EPA Mid-Continent Ecology Division, 6201 Congdon Blvd, Duluth, MN, 55804, USA; [2]University of Minnesota Duluth, Duluth, MN, 55812, USA. **Remote sensing and underwater glider observations of a springtime plume in western Lake Superior.**

Plumes are commonly observed in satellite imagery of western Lake Superior following storm events, and represent a significant cross-shelf pathway for sediment and other constituents. However, their subsurface extent is poorly understood. This study reports results from plume observations following a storm in late April 2016 using satellite remote sensing and an autonomous Slocum electric glider, which transected the plume-impacted waters 12 times over 9 days, completing over 2000 vertical profiles with a horizontal resolution scale of 100 m. Daily 250 m resolution band 1 MODIS surface reflectance imagery indicated the plume extended 25 km offshore, and coincident 1 km MODIS SST observations indicated the plume was warmer than the surrounding offshore waters. Glider observations of optical backscatter indicated the plume extended vertically through the water column over 50 m to the bottom. We used the combined satellite and glider observations to estimate the plume volume and additional glider observations of temperature and chlorophyll and CDOM fluorescence to assess the effect of springtime plumes on the lake's biogeochemical cycling. *Keywords: Lake Superior, Sediment transport, Remote sensing, Coastal processes.*

MCKINNON, E. and PATE, J., Love Your Greats, 11 Main Street North POBox 94, Bayfield, ON, N0M1G0, CANADA. **A Citizen Engagement Approach to Water Advocacy: Experiences from eXXpedition Great Lakes 2016.**

The Great Lakes suffer from considerable microplastic contamination. Despite this awareness, citizens around the lakes struggle to take action. With over 80% of plastic debris in the world's water bodies being contributed from land, the solutions for eliminating microplastics have to come from changes in consumer behaviour and by stopping contamination at the source. "eXXpedition Great Lakes 2016" was designed as a one day mass engagement event to bring the science of microplastics to citizens across the region, allowing them to experience first hand the presence and impact of this pollution. On this day, the largest, simultaneous water sampling event in history, hundreds of volunteers collected water samples and conducted shoreline clean-ups on the Great Lakes. Sailing vessels led by female scientists specializing in plastic pollution, human and environmental health were also launched from key cities in both Canada and the United States. The approach was to utilize the power of citizen engagement to promote clean-water advocacy and action in North America. The scope and results of this event will be discussed, with an emphasis on sharing the experiences of the citizen scientists who participated.
Keywords: Microplastics, Citizen science, Environmental education.

MCLAUGHLIN, C.[1] and KRANTZBERG, G.[2], [1]Bay Area Restoration Council, Hamilton, ON, L8S 4K1, CANADA; [2]McMaster University, Hamilton, ON, L8S 4K1, CANADA. **Remedies for improved development and implementation of Remedial Action Plans in the Great Lakes.**

Remedial Action Plans (RAPs) continue to be the principal program to operationalize the ecosystem approach to restoring Areas of Concern (AOC) in the Laurentian Great Lakes. In operation since 1987, progress on balance has been variously slow and disappointing. The RAP program has been continued following amendments to the Great Lakes Water Quality Agreement in 2012 but has received very little systematic inspection of its strengths and limitations. Further, the 2012 Agreement calls for a "nearshore framework" but the process of understanding place-based governance methods as developed under RAPs has not been sufficiently appreciated. In this context, we conducted a three-round online and anonymous Policy Delphi involving several dozen experts in the development and implementation of RAPs across the Great Lakes basin within government, industry, academia and civil society. We collected their direct knowledge

of the strengths and limitations of RAPs. We distilled that knowledge, asking study participants to further reflect on what worked and what did not work in their experience as RAP practitioners. We found a diversity of opinion on what ails or benefitted the RAP program, and a consensus on the desire to move forward with all of the seven governance options that emerged and that were ranked by participants. *Keywords: Policy Delphi, Governance, Remedial Action Plans.*

MCLEOD, A.M.[1] and HAFFNER, G.D.[2], [1]Memorial University of Newfoundland, 232 Elizabeth Ave, St. John's, NL, A1B 3X9, CANADA; [2]University of Windsor, 401 Sunset Ave, Windsor, ON, N9B3P4, CANADA. **Their Lasting Legacy: Insights into Foodweb Ecology Using Contaminant Tracers.**

Freshwater systems are experiencing a myriad of direct and indirect pressures (e.g. overfishing and stocking vs. climate change), however, methods of assessing these effects on food web structure and function are required to truly understand and anticipate their influence. Here, we use polychlorinated biphenyls (PCBs), a legacy pollutant found in aquatic systems across the globe, to track energy transfer and consumption efficiencies across trophic levels in a system in peril. The Lake Huron food web is experiencing substantial change including the invasions of dreissenid mussels and the round goby, increased oligotrophication, and the loss of a primary forage fish, the alewife. By using individual consumption efficiencies, we are able to illuminate basin specific differences in energy transfer driven by environmental and ecological differences. In addition, we can demonstrate a general decline in consumption efficiency with increasing trophic level across species including forage fish and top predators. Further, these decreases in consumption efficiency showed marked basin specific differences, with lake trout in the North Channel demonstrating the lowest consumption efficiency of all three basins. This is likely a result of higher densities of prey fish in the North Channel and hence a lower necessity of efficiency. *Keywords: Lake Huron, Food chains, Lake trout.*

MCMANUS, C.M., MCEVOY, J.L., and KARPOVICH, D.S., Saginaw Bay Environmental Science Institute at Saginaw Valley State University, 7400 Bay Road, University Center, MI, 48710, USA. **Coliform Bacterial Counts in Sediment and Water at Bay City State Recreational Area.**

High *Escherichia coli* counts at some beaches in Michigan can result in beach closings. Analysis of sediments and water samples from Bay City Recreational Area revealed that there is a positive correlation between wind and rain events and increased *E. coli*/coliform concentrations. *E. coli* concentrations have been found as high as 350 colony forming units (CFUs) per cubic centimeter of surface sand, and coliforms have been detected as high as

1380 CFUs/cc. Sediments acquired under the water were found to contain *E. coli* and other coliforms at concentrations as high as or higher than those found in sand obtained above the waterline. Following rain and/or wind events, underwater sediment samples harbored more *E. coli* and coliforms than after a stretch of low wind days with no rain. Water samples contained *E. coli* levels as high as 15,000 CFU/100mL following a significant rain and wind event. Total phosphorus levels as well as organic matter percentages were found to be higher in submerged sediment compared to sediment above the water line. Further studies are underway to determine whether correlations exist between phosphorus or organic matter levels and bacterial numbers, as well as whether the *E. coli*/coliforms are resident or transient microbes. *Keywords: Microbiological studies, Beach closings, Lake Huron, E. coli, Water quality, Sediment.*

MCNEISH, R.E.[1], MASON, S.A.[2], HOELLEIN, T.J.[1], and KELLY, J.J.[1], [1]Loyola University Chicago, 1032 West Sheridan Road, Chicago, IL, 60660, USA; [2]The State University of New York at Fredonia, 280 Central Ave, Fredonia, NY, 14063, USA. **Sources of Microplastic Contamination in Lake Michigan and Interactions with Aquatic Biota.**

Microplastic is a contaminant of concern worldwide which can reduce aquatic organisms' feeding capacity, adsorb persistent organic pollutants, and support pathogenic bacteria. Most microplastic research focuses on marine environments, but recent research showed microplastic concentrations in the Great Lakes are comparable to or higher than marine habitats. We investigated the sources of microplastic entering Lake Michigan and its biological interactions. Eight major tributaries of Lake Michigan were sampled for microplastic in surface waters, benthic sediments, and aquatic biota. Surface water microplastic concentrations were ~13 x greater in an agriculture dominated watershed compared to a forested watershed, and showed the same abundance, variation, and composition as coastal marine environments. *Neogobius melanostomus* (round goby) had the highest concentration of gut microplastic (~ 20 pieces/fish) compared to all other fish taxa, and had a positive correlation between body size and number of microplastic pieces per fish ($r^2 = 0.71$). Results show microplastic is common in aquatic food webs of major Lake Michigan tributaries, and that agriculture dominated watersheds may be key sources of microplastic. Ongoing work will incorporate these data with microplastic in sediment and macroinvertebrate taxa. *Keywords: Microplastics, Lake Michigan, Fish.*

MEEK, M.H.[1], BAERWALD, M.R.[2], STEPHENS, M.R.[3], GOODBLA, A.[2], MILLER, M.R.[2], TOMALTY, K.M.[2], and MAY, B.P.[2], [1]Michigan State University, 288 Farm Lane, East Lansing, MI, 48823, USA; [2]University of California, Davis, One Shields Dr, Davis, CA, 95616, USA; [3]University of California, Merced, 5200 North Lake Rd., Merced, CA, 95343,

USA. **Genomics to the Rescue--Improving Conservation of Imperiled Fish Populations.**

Our understanding of how to incorporate new genomics techniques into management is still in its infancy. In this talk, we provide an overview of how genomic study can directly inform the conservation and management of imperiled fish populations, using Chinook salmon (Oncorhynchus tshawytscha) and brook trout (Salvelinus fontinalis) as case studies. Both species are imperiled in their native range and suffering from the negative effects of anthropogenic change. We demonstrate how genomic DNA sequencing can be used to identify management units and assign individuals back to their natal populations. Additionally, we show how RNA sequencing can be leveraged to identify habitat areas of low quality, which are causing stress to individuals, as well as understand how the effects of climate change may impact populations in the future. This work is vastly improving our ability to effectively monitor and manage these imperiled species and we discuss applicability of these methods to fish species found in the Great Lakes. *Keywords: Genetics, Salmon, Conservation.*

MEHLER, K., BURLAKOVA, L.E., and KARATAYEV, A.Y., Great Lakes Center at SUNY Buffalo State, 1300 Elmwood Ave, Buffalo, NY, 14222, USA. **The Niagara River from a benthic perspective: What has been done and what needs to be done.**

The Niagara River has long been recognized as an essential part of the Great Lakes ecosystem. Due to its importance as a commercial and recreational waterway and because of its history of receiving large amounts of industrial wastewater, several benthic surveys have been done over the past 50 years. However, habitat data important for explaining benthos distribution patterns were lacking. Between 2014 and 2016 in collaboration with USFWS we generated bottom habitat maps, including substrate, bathymetry, near-bottom flow, and shear stress. Furthermore, we conducted an extensive benthic survey to assess diversity, abundance and spatial distribution of benthic communities, and to compare the current community with historical data. However, information on large-scale environmental data and benthos is restricted to the lower Niagara River. To better understand the ecosystem as a whole, both biological and physical habitat data need to be extended to the entire length of the river. This data can further be used to assess the benthic biomass available for higher trophic levels, to assess fish spawning areas and can be used as a basis to identify habitat quality from which effective management strategies in the Niagara River ecosystem can be developed. *Keywords: Niagara River, Benthos, Habitats.*

MENZA, C.[1], SAUTTER, W.[1], KENDALL, K.[1], COSTA, B.[1], REIF, M.K.[2], and BATTISTA, T.[1], [1]NOAA / National Centers for Coastal Ocean Science, 1305 East West

Highway, Silver Spring, MD, 20910, USA; [2]U.S. Army Engineer Research and Development Center, 7225 Stennis Airport Rd. Suite 10, Kiln, MS, 39556, USA. **Using LIDAR Surveys to Map Habitats and Archaeological Sites in Western Lake Michigan.**

Recent changes in Lake Michigan's water clarity have exposed large expanses of shallow lakebed areas to aerial imagery and other remote sensing technologies. The Joint Airborne LIDAR Bathymetry Technical Center of Expertise collected airborne laser scanning LIDAR (LIght Detection And Ranging) along Lake Michigan's coasts in 2008 and in 2012, offering unparalleled high-resolution bathymetric data in shallow areas. We used coastal LIDAR data to identify and characterize nearshore lakebed habitats and submerged archaeological sites in the proposed Wisconsin-Lake Michigan National Marine Sanctuary, an area that ranges along the western shore of Lake Michigan off Wisconsin. We developed benthic habitat maps using a combination of bathymetric derivatives (e.g., slope, rugosity, curvature), principal components analysis and edge-based segmentation, and we explored LIDAR returns for new information at known archaeological sites. Our coastal maps will offer new substrate, hazard and archaeological information to coastal managers tasked with maintaining lake-derived ecosystem services and protecting the exceptional historic and recreational value of the area. *Keywords: Lake Michigan, Remote sensing, Habitats.*

MEREDITH, C.S.[1], HOFFMAN, J.C.[2], TREBITZ, A.S.[2], PILGRIM, E.[3], MARTINSON, J.[3], and OKUM, S.[4], [1]National Research Council, EPA Mid-Continental Ecology Division 6201 Congdon Avenue, Duluth, MN, 55804, USA; [2]USEPA, EPA Mid-Continental Ecology Division 6201 Congdon Avenue, Duluth, MN, 55804, USA; [3]USEPA, 26 Martin Luther King Drive, Cincinnati, OH, 45268, USA; [4]ORISE, EPA-26 Martin Luther King Drive, Cincinnati, OH, 45268, USA. **Characterizing Lake Superior Zooplankton Communities Using Occupancy Modeling and DNA-based ID.**

Community composition of zooplankton in Lake Superior has shifted over the last several decades. This shift been attributed to factors including increasing temperatures, alteration of the predatory fish community, and the introduction of exotic species. However, our ability to track these changes into the future will depend on how well we can monitor their presence and abundance given that zooplankton are patchily distributed. To understand how spatial variation can influence detection, we collected multiple zooplankton samples within the same locations extending from nearshore areas of Western Lake Superior to the open lake. We used occupancy modeling to examine the probability of detecting specific taxa under different environmental conditions. We also explored how species composition varied between samples collected within similar geographic locations. As expected, some taxa exhibited high detection probabilities, while other taxa were less frequently detected when present. Collecting additional replicates in spatially diverse areas may allow for better

characterization of zooplankton communities. The use of DNA meta-barcoding for identification, which is being implemented as part of this project, may also improve our ability to detect spatial patterns of uncommon and/or invasive taxa. *Keywords: Zooplankton, Detection, Lake Superior, Metabarcoding, Invasive species.*

MEYER, A.R.[1], ROHN, B.G.[1], VIRGILIO, S.A.[2], TEWKESBURY, J.[3], and RUMPLE, S.T.[1], [1]USACE, Detroit District, 477 Michigan Avenue, Detroit, MI, 48226, USA; [2]U.S. EPA, Region V, 77 W. Jackson, Chicago, IL, 60604, USA; [3]Michigan Department of Environmental Quality, 27700 Donald Court, Warren, MI, 48092, USA. **Clinton River Area of Concern: Lessons Learned During Design of Four GLRI Projects.**

The Clinton River was designated an Area of Concern (AOC) in 1987 because of high pollutant levels and negatively impacted biota. This AOC includes the entire Clinton River Watershed as well as the portion of Lake St. Clair immediately downstream from the mouth of the river. The U.S. Environmental Protection Agency (EPA) has committed to the delisting of this AOC and in 2015 awarded $20 million to complete projects related to the loss of fish and wildlife habitat and degradation of fish and wildlife populations beneficial use impairments (BUIs), collectively called the fish and wildlife BUIs. The U.S. Army Corps of Engineers (USACE) Detroit District entered into an Interagency Agreement with the EPA to design and implement four habitat projects in the Clinton River AOC. Upon completion, these will contribute to the removal of the fish and wildlife BUIs. Design is underway or complete and construction on these projects is expected to begin in summer/fall 2017. Project components include bank stabilization, establishment of emergent wetlands, and natural stream channel design. Here we present different strategies employed and challenges faced during the design phase, as well as some of the benefits of working under an Interagency Agreement on AOC related projects. *Keywords: Great Lakes Restoration Initiative (GLRI), Area of Concern, Habitats, Clinton River.*

MEYER, D.N.[1], CROFTS, E.J.[2], and BAKER, T.R.[3], [1]Department of Pharmacology, School of Medicine, WSU, Detroit, MI, USA; [2]Institute of Environmental Health Sciences; Wayne State University, Detroit, MI, USA; [3]Institute of Environmental Health Sciences; Department of Pharmacology, WSU, Detroit, MI, USA. **Environmental contaminants in Detroit waterbodies effects: on zebrafish development and reproduction.**

Scientific and public concern is growing in response to ongoing reports of contaminants of emerging concern (CECs) and endocrine-disrupting chemicals (EDCs) in waterways due to their potential effects on wildlife and human health. These chemicals include pharmaceutical, personal care, agricultural, and industrial byproducts that enter the waterways via purposeful dumping, runoff, and wastewater treatment plants. Our lab utilizes the zebrafish model to assess how chronic exposure to EDCs can affect fertility, skeletal development and immune function in adults and subsequent generations. We also study the genetic and epigenetic changes associated with these phenotypes which are translatable to human health and development. In this study, we are evaluating the effect(s) of early developmental exposure to raw water (incoming river water) at the Great Lakes Water Authority Water Works Park Pilot Plant on reproductive capacity, sex ratio, and survival in controlled experiments with laboratory fish. Implications of this research include identifying etiologies of environmentally-induced disease in humans and anthropogenic pressures on reproductive capacity of wild fish populations *Keywords: Fish, Detroit River, Environmental contaminants.*

MEYER, K.A.[1], OSANTOWSKI, E.S.[2], WARREN, G.J.[2], and YUSIM, M.[3], [1]ORISE Fellow, U.S. EPA Great Lakes National Program Office, 77 W Jackson, Chicago, IL, 60604, USA; [2]U.S. EPA Great Lakes National Program Office, 77 W Jackson, Chicago, IL, 60604, USA; [3]Contractor, Federal Occupational Health, Chicago, IL, USA. **Particulate Nutrients in the Great Lakes: Analyzing a 20-year dataset.**

The U.S. Environmental Protection Agency Great Lakes National Program Office (GLNPO) has collected water samples for particulate nutrient analysis from all of the Great Lakes since 1997. Samples are collected during GLNPO's annual spring and summer surveys across the Great Lakes basin. This annual monitoring has resulted in a long-term dataset of particulate phosphorus, particulate nitrogen, particulate carbon, and total suspended solids. In this study, we assess temporal trends of particulate nutrients, compare trends among lakes, and determine how nutrient stoichiometry (e.g. Redfield's ratio) is changing over time in the Great Lakes. The results will be compared to other long-term datasets, including chlorophyll-a, to investigate changes associated with primary productivity trends across the lakes. *Keywords: Nutrients, Particulates, Comparison studies, Great Lakes basin.*

MEYER, K.A.[1], KREIS, R.G.[3], NETTESHEIM, T.G.[2], RYGWELSKI, K.R.[3], and WARREN, G.J.[2], [1]ORISE Fellow, U.S. EPA Great Lakes National Program Office, 77 W Jackson, Chicago, IL, 60604, USA; [2]U.S. EPA Great Lakes National Program Office, 77 W Jackson, Chicago, IL, 60604, USA; [3]Retired, U.S. EPA ORD/NHEERL/MED, Grosse Ile, MI, USA. **Atrazine Concentrations in Lake Michigan Overtime: Investigating the impacts of usage changes.**

The U.S. Environmental Protection Agency's Great Lakes National Program Office (GLNPO) and partners instituted the Lake Michigan Mass Balance (LMMB) Study to measure and model the concentrations of representative pollutants within important compartments of the Lake Michigan ecosystem. The goal of the LMMB Study was to develop a sound, scientific base of information to guide future toxic load reduction efforts at the federal, state, tribal, and local levels. Atrazine, an herbicide mainly used on corn crops, was one of the chemicals investigated as part of the LMMB. Atrazine concentrations in Lake Michigan depend on tributary loadings, wet deposition, and lake retention time. In this study, we examine these influences to investigate plausible causes for the reduced atrazine concentrations observed in 2015 - 20 years after the original data was collected. These measured atrazine concentration trends are also compared to predicted concentrations generated by different LMMB model scenarios. We focus on atrazine usage data, both in the Lake Michigan basin and across the United States, over the last 25 years to evaluate the trends in atrazine concentrations overtime. *Keywords: Atrazine, Lake Michigan, Environmental contaminants.*

MEYER, K.A.[1], DAVIS, T.W.[2], WATSON, S.B.[3], and DICK, G.J.[4], [1]Cooperative Institute for Limnology and Ecosystems Research (CILER), 4840 South State Road, Ann Arbor, MI, 48108, USA; [2]NOAA Great Lakes Environmental Research Laboratory, 4840 South State Road, Ann Arbor, MI, 48108-9719, USA; [3]Environment and Climate Change Canada, Burlington, ON, CANADA; [4]University of Michigan, Department of Earth and Environmental Sciences, 1100 North University Avenue, Ann Arbor, MI, 48109-1005, USA. **The impact of nitrogen form and availability on the toxicity of *Microcystis* blooms in Lake Er.**

There is growing evidence for the importance of nitrogen in shaping <Microcystis cyanobacterial harmful algal bloom structure and toxicity in lakes and estuaries worldwide. In particular, observations in lake blooms show a succession between toxic and non-toxic genotypes, changes in expression of toxin genes, and shifts in ratios of microcystin congeners produced that coincide with shifts in nitrogen availability. We used comparative genomics to identify the diversity and expression of nitrogen uptake pathways in cultured isolates and of *Microcystis* from the lower Great Lakes. Data were then used to analyze a shift from high to low toxin production coinciding with a change from high to low nitrate concentrations during a *Microcystis* bloom in Lake Erie in 2014. Combined, this provides insight into the up- and down-regulation of gene pathways associated with toxin production and differences in nitrogen availability in individual *Microcystis* strains and naturally occurring blooms. This work builds a mechanistic understanding of the relationships between toxin production, physiological state, and environmental parameters which improves the understanding of the drivers behind microcystin production in *Microcystis* blooms.
Keywords: Harmful algal blooms, Genomics, Microcystis, Nutrients.

MIDDEN, W.R.[1] and SOLOHIN, E.[2], [1]Bowling Green State Univresity, NWO/COSMOS, 241 Math Science Bldg, Bowling Green, OH, 43403, USA; [2]Indiana University, School of Public and Environmental Affairs, MSB II Room 444, 702 N Walnut Grove Ave, Bloomington, IN, 47405, USA. **Extremely High Dissolved Phosphorus from No-Till Fields without Fertilizer Incorporation.**

Harmful algal blooms (HABs) have been increasing in intensity in the western basin of Lake Erie for the last 10-15 years. This is arising despite particulate phosphorus load remaining about the same or declining over this period. Instead, increase in dissolved reactive phosphorus (DRP) appears to be the primary factor responsible for the HAB increase. An important question is what accounts for the increase in DRP load and what practices can be changed to achieve the most cost-effective decrease in DRP. In a study of nutrient concentrations in surface runoff from long-term no-till (NT) compared to conventional tillage (CT) fields we observed greater than ten times higher concentrations of DRP in surface runoff from the NT plots. Except for tillage, the NT plots had been treated identically to the CT plots since the 1960s in a continuous crop yield study. The extremely high level of DRP in surface runoff from the NT plots is attributed to complete lack of incorporation of the ammonium phosphate fertilizer that was broadcast applied. This represents one of the most extreme examples of high levels of DRP from agriculture and highlights the importance of fertilizer incorporation as an important means of reducing DRP loads in the western Lake Erie watershed. *Keywords: Nutrients, No-till agriculture, Environmental effects, Nutrient management, Harmful algal blooms, Agricultural best management practices.*

MIDDLEBROOK AMOS, M.[1], BLUME, L.J.[2], BUCHER, A.[1], TELECH, J.W.[1], BENJAMIN, E.[1], and SCHOFIELD, J.[1], [1]CSRA, 6361 Walker Lane, Suite 300, Alexandria, VA, 22310, USA; [2]US EPA Great Lakes National Program Office, 77 W Jackson Blvd, Chicago, IL, 60604, USA. **The Environment Depends on You - You Depend on Quality Resources.**

While planning, implementing, and reporting on environmental monitoring projects, it is helpful to rely on existing tools, examples, training, and guidance to streamline processes, provide best practices, and capitalize on others' efforts. However, in our world of information overload, finding the appropriate resources to support these projects can be challenging. Alternatively, organizations disseminating information often struggle with ensuring information remains current and relevant and is in the hands of those who need it most. With the advent of the Great Lakes Restoration Initiative (GLRI), US EPA Great Lakes National Program Office (GLNPO) recognized the critical need to develop and disseminate quality-related resources to assist collaborators during all phases of projects generating or using environmental information. Years into the GLRI, GLNPO has not lost

sight of the value of quality resources and continues to improve existing tools, evaluate opportunities for quality improvement, and provide a forum for information sharing. This presentation highlights key resources developed or recently enhanced by GLNPO (including a demonstration of GLNPO's QA Resources site) and new resources anticipated to be released in 2017. *Keywords: Education, Environmental education, Outreach.*

MIDWOOD, J.D.[1], MILNE, S.[2], LEISTI, K.[1], REDDICK, D.[1], and DOKA, S.E.[1], [1]Fisheries and Oceans Canada, 867 Lakeshore Rd., Burlington, ON, L7S1A1, CANADA; [2]Milne Technologies, 91 Pinecrest Ave., Keene, ON, K0L2G0, CANADA. **Short-term response of fish to a turbid river plume.**

Rain events result in a change in the discharge patterns of large rivers and, in most instances, result in increased discharge of water that is considerably more turbid than the receiving waters. In freshwater ecosystems, the influence of these river plumes on fish populations and behaviour has received little attention. In the summer of 2016 a large storm event in Toronto, Ontario resulted in a considerable plume of turbid water entering the harbour from the Don River. Here we compare the size distribution, composition and behaviour of fish within this plume to those in the comparatively clear adjacent waters. These data were collected during the day using multifrequency split-beam hydroacoustics and mid-water trawling. Preliminary results suggest that while species composition and size distributions between the two areas were similar, fish in the turbid plume were more dispersed (less schooling), a behavioural pattern more indicative of nighttime conditions. Turbid discharge events therefore disrupt the normal diel patterns of fish schooling behaviour, possibly as a result of a reduction in predation risk. *Keywords: Fish, Fish behavior, Turbidity.*

MIFSUD, D.[1], GREENWALD, K.R.[2], STAPLETON, M.[1], STEDMAN, A.[2], SUTHERLAND, J.L.[2], LEIGH, D.[2], KIK IV, R.[3], CRAIG, J.[4], BOASE, J.C.[5], FRANCIS, J.[6], THOMAS, M.V.[6], BRIGGS, A.S.[5], CHIOTTI, J.A.[5], ROSEMAN, E.[4], KENNEDY, G.[4], and BOHLING, M.E.[7], [1]Herpetological Resource and Management, P.O. Box 119, Chelsea, MI, 48118, USA; [2]Eastern Michigan University, 441 Mark Jefferson Science Complex, Ypsilanti, MI, 48197, USA; [3]Belle Isle Aquarium, 5841 4th St., Detroit, MI, 48202, USA; [4]U.S. Geological Survey, 1451 Green Road, Ann Arbor, MI, 48105, USA; [5]U.S. Fish and Wildlife Service, 7806 Gale Rd., Waterford, MI, 48381, USA; [6]Michigan Department of Natural Resources - Fisheries Division, 33135 S. River Rd, Harrison Township, MI, 48045, USA; [7]Michigan Sea Grant, 1674 Fort St., Lincoln Park, MI, 48146, USA. **Assessment of the Mudpuppy: Conserving a Focal Species of the St. Clair-Detroit River System.**

The Mudpuppy (*Necturus maculosus*) serves a critical role as an environmental health indicator as well as the obligate host to the State Endangered Salamander Mussel (*Simpsonaias ambigua*). The species was recently elevated to Special Concern in Michigan and declining throughout the Great Lakes Region. This species was also identified as a focal species for the St. Clair-Detroit River System (SCDRS). Numerous data gaps exist for this fully aquatic salamander throughout its range. Given their significant declines and ecological importance, this multi-faceted, collaborative project was initiated to evaluate the distribution, health, and genetic structure of Mudpuppies along the SCDRS and to restore Mudpuppy habitat. This work is applicable throughout species range making it an important step in the future conservation of Mudpuppy throughout the Great Lakes region. *Keywords: Amphibians, Bioindicators, Ecosystem health.*

MILLER, C.J., OLSON, J., XU, L., AMOOZEGAR, S., and SHI, W., Wayne State University, 5050 Anthony Wayne Drive, Detroit, MI, 48105, USA. **Detroit Regional Source Water Monitoring Data Platform.**

Helthy Urban Waters (HUW) at Wayne State University is collaborating with MDEQ Office of the Great Lakes (OGL), SEMCOG, and regional water utilities to rejuvenate and expand the Huron to Erie Drinking Water Monitoring Network. HUW and partners are completing assessments at each water treatment plant to gain insights into failures and successes in the drinking water monitoring network. Furthermore, HUW is leading the database management component of the drinking water monitoring network. Researchers have developed a database and website to provide storage and retrieval of all data collected by the network in the past and into the future. Development of search protocols are ongoing to ensure that this tool addresses needs of regional water researchers, as well as urban watershed researchers world-wide. *Keywords: Monitoring, Data, Detroit River, Drinking water.*

MILLER, J.[1], SAARINEN, J.[2], JOSEPH, C.[1], and SCHAEFFER, J.S.[1], [1]USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105, USA; [2]New College, Sarasota, FL, USA. **Mapping Application for Lower Maumee River (MALMR) characterizes habitat for BUI removal planning.**

The Maumee Area of Concern (AOC) is so designated due to legacy contaminants, sedimentation, and habitat loss, with the lower river being especially problematic. To date, very few BUI removal projects have been planned or executed in the lower river, partly due to lack of understanding of lower river habitat structure and function. A Mapping Application for the Lower Maumee River (MALMR) characterizes historic and existing aquatic and shoreline habitats in order to identify areas with the greatest potential for restoration within the AOC delisting framework. This "smart" map includes not only static features, such as LIDAR-generate elevation and side-scan-sonar bathymetry, but also dynamic system processes within Great Lakes rivermouths, such as mixing of river water and lake water due to seiche activity and seasonal flooding. The online, interactive tool provides for analysis of habitats at multiple geographic scales by partners not only within but also outside the BUI delisting process. It communicates the potential natural values and services of the river for surrounding communities interested in community and riverfront revitalization. The MALMR provides a template for other Great Lakes urban rivermouth communities interested in understanding historic and existing habitats and planning for ecosystem service restoration. *Keywords: Coastal ecosystems, Deltas, Habitats.*

MILLER, Z.A., WATKINS, D.W., and AUER, M.T., Michigan Technological University, 1400 Townsend Drive, Houghton, MI, 49931, USA. **Engaging High School Students in Urban Wet Weather Flow Management.**

Combined Sewer Overflows (CSOs) carry a mixture of raw sewage and stormwater, discharging into the natural waterways and adversely affecting the environment and public health. Cleveland, Ohio, where the Cuyahoga River notoriously burned in the 1950s and 1960s, is one of many U.S. cities with widespread CSO discharge problems. The Northeast Ohio Regional Sewer District (NEORSD), responsible for managing wastewater and stormwater in the Greater Cleveland Area, is investing $3 billion in engineering alternatives to reduce CSO discharge volumes. A comprehensive modeling study was done to help decision makers understand how to best allocate resources to address the CSO problem and improve the overall health of streams, beaches and shorelines in and around Cleveland. This presentation outlines a proposed high school curriculum in which students learn about the Clean Water Act, the causes and effects of urban water quality impairments, and measures to improve urban water quality. Classroom activities include analysis of EPA Storm Water Management Model (SWMM) results, and field trips include a visit to a wastewater treatment plant, viewing sewer outfalls, and monitoring water quality in streams and at beaches. *Keywords: Education, Water quality, Lake Erie, Urban watersheds.*

MILLIGAN, M.S.[1], DOUCETT, E.[1], FERNANDO, S.[2], CRIMMINS, B.S.[2], HOLSEN, T.M.[2], HOPKE, P.K.[2], and PAGANO, J.J.[3], [1]SUNY Fredonia, Fredonia, NY, 14063, USA; [2]Clarkson University, Potsdam, NY, 13699, USA; [3]SUNY Oswego, Oswego, NY, 13126, USA. **Targeted Analysis of Emerging Contaminants in Great Lakes fish using GC/MS/MS Methodologies.**

As part of our ongoing work with the EPA-sponsored Great Lakes Fish Monitoring and Surveillance Program, we have employed a number of different analytical techniques,

such as comprehensive two dimensional gas chromatography with time-of-flight mass spectrometry (GCxGC-TOF), to identify potential emerging contaminants of concern in Great Lakes fish. Unlike many classical legacy contaminants, some of these candidate emerging contaminants are quite polar and/or labile, and as a result traditional clean-up methods involving basic or acidic silica, alumina, or carbon columns result in the partial or complete loss of these compounds before subsequent gas chromatographic analysis. Accordingly, we have been developing gas chromatographic methods on fish tissue extracts that have not been subjected to column clean-up techniques. These extracts have very complex matrices, and standard GC/MS-SIM methods can be ineffective when trying to generate reliable quantitative data on targeted compounds. We have had success in the analysis of these raw extracts using GC/MS/MS for emerging contaminants such as the highly polar chloro- and bromo-methoxy phenol congeners. Using this technique, we have identified many isomers of these compounds at quite low method detection limits.
Keywords: Environmental contaminants, Fish, Mass spectrometry.

MILT, A.W.[1], DORAN, P.J.[2], FERRIS, M.C.[1], MOODY, A.T.[1], NEESON, T.M.[3], O'HANLEY, J.[4], and MCINTYRE, P.B.[1], [1]University of Wisconsin - Madison, Madison, WI, USA; [2]The Nature Conservancy, Lansing, MI, USA; [3]The University of Oklahoma, Norman, OK, USA; [4]University of Kent, Cantebury, ENGLAND; [5]Blankity Blank, Blankington, USA. **Tradeoffs among sea lamprey and beneficiary species from multi-species planning of barrier removals.**

Dam removals and culvert upgrades are two essential strategies to restore aquatic connectivity for beneficiary migratory fish; strategies which can also promote the spread of invasives. In the Great Lakes basin, the tradeoff between opening habitat for desirable fishes and invasive sea lamprey is widely recognized, yet the potential for balancing this tradeoff has never been quantified. We assessed how optimally planning barrier removals to maximize habitat access for beneficiary species is affected by limiting access for sea lamprey. We contextualize our results by testing how simultaneously planning for multiple desirable species further reduces access for any single beneficiary. We also explored the effect of budget limits on the tradeoff. For moderate limits on sea lamprey access and removal budgets, limiting sea lamprey access generally had a much smaller effect on beneficiary habitat access than planning for multiple species or the removal budget. Our results show that, while limiting habitat access for invasive species has quantitative consequences for beneficiary species, it may not be the major contributor to interspecies tradeoffs. Recognizing this may help set acceptable limits on access for invasives, thereby indicating a path forward regarding difficult decisions about barrier removals. *Keywords: Sea lamprey, Connectivity, Barrier removal.*

MING, T.[1], VANDERPLOEG, H.A.[2], ROWE, M.D.[3], FANSLOW, D.L.[2], STRICKLER, J.R.[4], MILLER, R.J.[3], JOHENGEN, T.H.[3], DAVIS, T.W.[2], and GOSSIAUX, D.C.[2], [1]School of Natural Resources & Environment, University of Michigan, 440 Church St., Ann Arbor, MI, 48109, USA; [2]NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Rd., Ann Arbor, MI, 48108, USA; [3]Cooperative Institute for Limnology and Ecosystems Research, 440 Church St., Ann Arbor, MI, 48109, USA; [4]Great Lakes WATER Institute, University of Wisconsin - Milwaukee, 600 E. Greenfield Ave., Milwaukee, WI, 53204, USA. **Effect of light exposure and nutrients on buoyancy of *Microcystis* colonies.**

Understanding the vertical distribution of *Microcystis* spp. is important for improving satellite-derived estimates of bloom biomass and for predicting the transport of blooms. For example, the Lake Erie HAB Tracker forecast model is initialized from satellite imagery, then predicts the transport and vertical distribution of harmful algal blooms (HABs) in Lake Erie over a five-day period. To improve vertical distribution predictions, we used novel videographic methods to determine effects of light intensity, colony size, as well as dissolved and particulate nutrient concentrations on the buoyant velocities of *Microcystis* colonies collected from western Lake Erie. We incubated whole water samples in two 2L borosilicate bottles in an outdoor incubator maintained at ambient lake temperatures. Light levels were varied to represent day and night conditions for a surface scum or turbulent mixed layer distributions. After an overnight dark adaption, subsamples from each bottle were collected in the morning and evening, then buoyant velocities were measured. In general, colonies were positively buoyant with rates increasing with colony size. However, varying nutrient and light conditions differentially impacted buoyancy rates of *Microcystis* colonies.
Keywords: Microcystis, Buoyancy, Nutrients, Colony size, Light.

MISHRA, S.[1], STUMPF, R.P.[2], BRIDGEMAN, T.B.[3], DAVIS, T.W.[4], JOHENGEN, T.H.[5], WYNNE, T.T.[2], MEREDITH, A.W.[1], and TOMLINSON, M.C.[2], [1]Consolidated Safety Services, Inc., 10301 Democracy Lane, Suite 300, Fairfax, VA, 22030, USA; [2]National Oceanic and Atmospheric Administration, National Centers for Coastal Ocean Science, 1305 East West Highway, Silver Spring, MD, 20910, USA; [3]Department of Environmental Sciences/Lake Erie Center, University of Toledo, 6200 Bayshore Rd., Oregon, OH, 43616, USA; [4]4National Oceanic and Atmospheric Administration, Great Lakes Environmental Research Laboratory, 4840 S. State Rd., Ann Arbor, MI, 48108, USA; [5]Cooperative Institute for Limnology & Ecosystem Research, 440 Church Street, Ann Arbor, MI, 48109, USA. **Relationships Between Field and Satellite Estimates of Cyanobacterial Bloom Severity in Western Lake.**

Cyanobacterial Harmful Algal Blooms (CHABs) are a serious water quality issue in western Lake Erie. We use field observations, MEdium Resolution Imaging Spectrometer

(MERIS) and Moderate Resolution Imaging Spectroradiometer (MODIS) data to estimate algal bloom severity during the study period (2003-2016). Field observations included two datasets- 1) biweekly *Microcystis* bio-volume measurements in the entire water column monitored by The University of Toledo, Lake Erie Center, and 2) weekly surface chlorophyll-a concentration collected by the joint NOAA Great Lakes Environmental Research Laboratory and University of Michigan Cooperative Institute for Limnology and Ecosystems Research monitoring program. The MODIS and MERIS datasets generate the Cyanobacteria Index (CI), which provides estimates of surface concentration of cyanobacterial chlorophyll. Individual images are composited over 10-day periods to get closer to a cyanobacterial biomass estimate for the entire water column. This study aims at investigating the closure between remotely derived and field-measured biomass to clarify the relationships between satellite and field estimates of bloom severity in western Lake Erie. *Keywords: Harmful algal blooms, Cyanobacteria, Remote sensing, Water Quality, Lake Erie.*

MISTRY, R. and ACKERMAN, J.D., University of Guelph, Department of Intergrative Biology, Guelph, ON, N1G 2W1, CANADA. **Flow, flux and feeding: Evidence for niche separation in freshwater mussels.**

The coexistence of species using the same resources is not well understood. We examined the clearance rates (*CR*) of 4 mussels species (*Lampsilis siliquoidea, Lampsilis fasciola, Ligumia nasuta*, *Villosa iris*) to determine whether they feed selectively on river seston and how this may vary with algal flux. The *CR* of all species increased linearly with flow chamber velocity, but exhibited saturation-like kinetics with algal flux. The *CR* of *Lampsilis* species (1) were higher for particles >10 um than for particles <10 um and (2) declined for most algal taxa with increasing algal flux, suggesting that the ability to discriminate among seston components decreases with increased flux. The *CR* of *Stephanodiscus* sp., *Chlorella* sp. and a pennate diatom by *L. fasciola* declined linearly with algal flux but the decline of *Chloromonas* sp. was nonlinear for *L. siliquoidea* and importantly, *CR* increased nonlinearly with *Stephanodiscus* sp. Differential use of algal taxa under different algal flux provides sufficient evidence for selective feeding, which may be evidence of niche partitioning for sympatric mussel species, and indicates the complex nature of bivalve feeding and habitat requirements. *Keywords: Mussels, Water currents, Hydrodynamics.*

MITCHELL, K.T.[1], PITCHER, T.E.[2], WILSON, C.C.[3], and NEFF, B.D.[1], [1]University of Western Ontario, London, ON, CANADA; [2]University of Windsor, Windsor, ON, CANADA; [3]Trent University, Peterborough, ON, CANADA. **Effects of dietary thiaminase on reproductive traits in three populations of Atlantic salmon.**

There have been multiple attempts to reintroduce Atlantic salmon into Lake Ontario, but these attempts have not yet produced a self-sustaining population. One potential obstacle is the introduction of invasive prey fishes into Lake Ontario, including alewife and rainbow smelt. These fishes contain high concentrations of the enzyme thiaminase, which breaks down the essential vitamin thiamine and can induce thiamine deficiency in salmon that consume this enzyme. We compared the effect of dietary thiaminase on reproductive traits in three Atlantic salmon populations (LaHave, Lac Saint-Jean, Sebago), which have previously been used in reintroduction efforts. We hypothesized that a high-thiaminase diet would affect reproductive traits and these effects would differ among the three populations. To test our hypotheses, we performed experimental crosses with our low- and high-thiaminase treatment individuals within populations and measured reproductive traits. We present data on the effects of dietary thiaminase levels on mortality, yolk conversion efficiency, specific growth rate, thiamine concentrations and sperm quality. We further use this data to assess the susceptibility of the three Atlantic salmon populations to a high-thiaminase diet, as is present in Lake Ontario, and inform best practices for managing the Atlantic salmon. *Keywords: Thiaminase, Salmon, Conservation.*

MOEGLING, S.[1] and VERHAMME, E.M.[2], [1]Cleveland Water Department, 1201 Lakeside Ave, Cleveland, OH, 44114, USA; [2]LimnoTech, 501 Avis Dr, Ann Arbor, MI, 48108, USA. **Optimizing Water Treatment at Cleveland Water.**

Water utility managers use a variety of information sources to optimize water treatment. Historically, raw water quality changes were noticed and subsequently analyzed once water was inside the plant, thereby leaving little time for reaction. Technology then progressed to permit remote analyses to be used for more advanced notice of impending quality changes that could be seen at the plant. Currently, satellite imagery, buoy mounted sondes, and predictive water models have emerged as the latest tools available to water utility managers, thereby affording an even greater advanced warning. Lake Erie supplies raw water for over 30 plants to 11 million people. Recent challenges with raw water quality (harmful algal blooms, hypoxia, taste and odor, etc.) make advance warning, to the point of accurate prediction, crucial to ensure safe water is provided. This presentation will give the Cleveland Water perspective on the tools that are available, how we use this information, the importance of networking information and communication, and a couple of real examples of how this information has made a difference. The presentation will conclude with one utility's perspective on future data needs, modeling needs, and concerns with data overload. *Keywords: Lake Erie, Drinking water.*

MOHAMED, M.N., Ontario Ministry of the Environment and Climate Change, 125 Resources Road, Toronto, ON, CANADA. **Eutrophication in the Laurentian Great Lakes basin, past, present, and future.**

The Laurentian Great Lakes (LGL) experienced eutrophication issues several decades ago. Mitigation strategies during this period included upgrades to waste water treatment plants (WWTP) as well as banning P in laundry detergents, resulting in a substantial reduction in P inputs from these point-sources. Additionally, agricultural conservation practices (CPs) were promoted widely in the basin to mitigate non-point source losses of P. Even though offshore P concentrations in all the lower LGL have fallen below target concentrations, eutrophication-related issues are occurring; mitigation of the current issues will be more challenging than in the past. While the reduction in P inputs from improvements in WWTP is relatively straightforward, the effectiveness of CPs is uncertain. Many other changes have also occurred in the ensuing decades, including changes in agricultural land use as well as changes in the timing of nutrient losses. In this presentation, an overview of past eutrophication in the LGL, and the efforts to reduce them, will be discussed. Additionally, with a focus on the Canadian side of the LGL basin, notable changes in the landscape, the timing and nature of nutrient losses, as well as perspectives on the understanding required to move forward, will be presented. *Keywords: Phosphorus, Eutrophication.*

MOLDAENKE, C.[1], DAHLHAUS, A.[1], DAHLHAUS, H.[1], KUEPPERS, S.[2], SANTIAGO-SCHUEBEL, B.[2], SCHMIDT, W.[3], and WAGNER, M.[3], [1]bbe Moldaenke GmbH, Preetzer Chaussee 177, Schwentinental, 24222, GERMANY; [2]Forschungszentrum Juelich GmbH, Leo-Brandt-Str., Juelich, 52428, GERMANY; [3]DVGW - Technologiezentrum Wasser, Wasserwerkstr. 2, Dresden, 01326, GERMANY. **A New Measuring Method as an Early Warning System for the Appearance of Cyanobacteria's Compounds.**

Concept and data of submersible and lab spectro-fluorometer are presented. This type of instrument is designed to estimate online a potential risk of the appearance of T&O compounds resp. toxins from cyanobacteria in raw water and drinking water. The principle is based on fluorescence measurements of 'free phycocyanin' (free or unbound phycocyanin), which is released from the chlorophyll in the thylakoid membrane and can be separately determined. The method has proven its potentials in the lab and in situ already. The estimation of risk described here depends on the cyanobacteria concentration in raw water, its physiological state and the effects of the treatment steps in the water works. The implementation of the principles of free phycocyanin has a big impact on the calculation of the photosynthetic activity of cyanobacteria. *Keywords: Cyanophyta, Free phycocyanin, Toxic substances, Taste and odor, Algae, Photosynthetic activity.*

MOLOT, L.A., York University, FES, 4700 Keel Street, Toronto, ON, M3J 1P3, CANADA. **Cyanobacteria N2 fixation: Review of benchtop studies and implications for N removal programs.**

One goal of eutrophication management is to lower the risk of cyanobacteria blooms, typically accomplished by lowering productivity with phosphorus (P) controls. However, some researchers have argued that dual nitrogen (N) and P controls would be more effective at preventing cyanobacteria blooms than P alone. The argument for removing both N and P is based on the hypothesis that if a system becomes N-limited, cyanobacteria N fixation rates will not be high enough to maintain productivity near previous levels but evidence in support of this is indirect. Several culturing studies directly examining the effect of removing N show that N fixers compensate biochemically for the high energy cost of fixation when supplied with sufficient nutrients in the absence of ammonium and nitrate. Biomass and growth rates were only slightly different under N2 than when grown under ammonium and nitrate which is consistent with results from the experimental fertilization of Lake 227. These and other studies at ELA and in Georgian Bay embayments show that N removal programs will not have a significant impact on the magnitude of cyanobacteria blooms unless they are deprived of essential micronutrients, especially ferrous iron. The most effective approach to bloom prevention is to ensure oxidized sediments with a suite of tools, including P controls. *Keywords: Eutrophication, Nitrogen, Cyanophyta, Nutrients.*

MONSHI, M.[1], MATTA, V.[1], ALAME, K.[1], REDDY, N.[1], MCELMURRY, S.P.[2], KASHIAN, D.R.[3], and PITTS, D.K.[1], [1]Dept Pharmaceutical Sciences, Wayne State University, 259 Mack Ave, Detroit, MI, 48202, USA; [2]Civil and Environmental Engineering, Wayne State University, 2100 Engineering Building, Detroit, MI, 48202, USA; [3]Biological Sciences, Wayne State University, 2125 Biological Sciences Building, Detroit, MI, 48202, USA. **Lethal and sub-lethal behavioral effects of triclosan and triclocarban, in Daphnia pulex.**

The polychlorinated antimicrobials, triclocarban (TCC) and triclosan (TCS), are used in a wide range of products including soaps, detergents, toothpaste, plastics, paint, toys, and clothing. The high volume use of TCC and TCS has resulted in widespread environmental contamination, and these compounds have been detected in both ground water and surface water. They are considered contaminants of emerging concern. The effects of TCC and TCS exposure (.01nM to 1μM) on Daphnia pulex survival were evaluated over a 5-day period in EPA water. The overall effect of chemical exposure was dependent on the type of chemical, exposure duration, and concentration (chemical x time x concentration interaction, $P<0.001$), but the concentration-dependent effects did not appear to follow a simple linear relationship over time. When survival was examined on day 5, the lowest concentrations that

showed significantly lower survival than control ($P<0.05$) for each of the treatments were as follows: TCC: 0.1µM, TCS: 0.01nM. An optical tracking assay was used to evaluate the acute sub-lethal behavioral effects of TCS on D. pulex swimming behavior over 24 hrs. All concentrations studied (0.5 µM to 8 µM) stimulated swimming behavior and significantly increased maximum accumulated distance traveled and altered the mean angular change in direction. *Keywords: Environmental contaminants, Endocrine disruption, Crustaceans.*

MONTGOMERY, F.A.[1], MANDRAK, N.E.[1], and REID, S.M.[2], [1]University of Toronto Scarborough, 1265 Military Trail, Scarborough, ON, M1C 1A4, CANADA; [2]Ministry of Natural Resources and Forestry, 300 Water St, Peterborough, ON, K9J 3C7, CANADA. **A habitat-based framework to predict and mitigate the impacts of drain maintenance on fishes.**

One third of the total global land viable for agricultural production now supports drainage systems. These drainage systems can provide important habitat for fishes, and in some cases fish species at risk, which are vulnerable to impact by maintenance activities. Predictive habitat-based models were used to predict suitable habitat for two species at risk in an agricultural drain: the Endangered Pugnose Shiner (*Notropis anogenus*) and the Special Concern Blackstripe Topminnow (*Fundulus notatus*). Spatial models were used to assess the impacts of proposed drain maintenance on the overall amount of suitable habitat, habitat patch size, and connectivity of habitat patches. Maintenance had a significant impact on habitat connectivity ($p=0.03125$; $p=0.035$) but did not significantly reduce the habitat patch size of isolated patches ($p=0.6875$; $p=1$). The amount of suitable habitat available after maintenance fell below the minimum area for population viability (MAPV) for the Pugnose Shiner, but not the Blackstripe Topminnow. This study provides a framework to quantify the impacts of maintenance on fish species at risk. Future impact assessments of drain maintenance should incorporate MAPV and habitat patch analysis, using predictive habitat models, into conservation and land-use management decisions. *Keywords: Fish, Conservation, Management.*

MOORE, D.J.[1] and MANDRAK, N.E.[2], [1]Central Lake Ontario Conservation Authority, 100 Whiting Avenue, Oshawa, ON, L1H3T3, CANADA; [2]University of Toronto Scarborough, 1265 Military Trail, Toronto, ON, M1C1A4, CANADA. **Importance of abiotic factors and vegetation for healthy coastal wetland fish communities.**

Lake Ontario coastal wetlands are under increasing stress due to numerous threats. Restoration and management of the remaining wetlands are necessary to ensure that ecosystem functions critical for Lake Ontario fisheries persist. This study uses long-term monitoring datasets, including 138 sampling events from 31 different wetlands, to examine

the relationship between fish community health and select abiotic and vegetation variables. Eight of 13 abiotic and vegetation variables were found to have significant relationships with fish community health including: total, submerged, and emergent vegetation; submerged aquatic vegetation IBI; water depth; turbidity; conductivity; and, water quality index. Ranges for each significant variable were summarized for each fish community health group to provide guidance when diagnosing impairment or setting restoration goals. An ordination of the fish and environmental data revealed high amounts of variation at sites with poor fish community health relative to excellent health, suggesting the multimetric approach provides valuable insight into community variability. The results from this study provide additional information and alternative methods for assessment of current conditions, target setting, and restoration success assessment for coastal wetland managers. *Keywords: Fish, Coastal wetlands, Biomonitoring.*

MOORE, L.P.[1], COOPER, M.J.[2], and UZARSKI, D.G.[1], [1]Central Michigan University, Mount Pleasant, MI, 48858, USA; [2]Northland College, Ashland, WI, USA. **Nutrient limitations in Great Lakes coastal wetlands: gradients and their influence.**

Coastal wetlands are an essential component of the Great Lakes ecosystem and are susceptible to anthropogenic influences, including nutrient runoff. Nutrient limitation occurs naturally when nutrients are in short supply. Nutrient loading can counteract limitation and fuel higher rates of primary production. We hypothesized that nutrient limitation would change along a gradient with shallow inner areas being more N-limited and deeper areas with more exposure to wave energy being more P-limited. Nutrient limitation was measured in wetlands of Saginaw Bay, the Les Cheneaux Islands and the Beaver Island Archipelago with Nutrient Diffusing Substrates amended with N, P, and N+P combined. Substrates were placed in inner, middle, and outer zones of each wetland for three weeks during the summers of 2015 and 2016. Periphyton biomass accrual was N-limited or N+P co-limited at most locations. Wetland position and wave exposure appeared to have little influence on nutrient limitation. Other factors such as temperature, light, and ambient nutrients also had little effect. However, nutrient limitation appeared greater at Beaver Island wetlands compared to Saginaw Bay wetlands suggesting that surrounding land use and nutrient runoff may be influencing nutrient limitation in these systems. *Keywords: Nutrients, Periphyton, Assessments.*

MOORE, T.S.[1], FENG, H.[1], RUBERG, S.[2], MUZZI, R.[2], BEADLE, K.S.[2], CONSTANT, S.A.[2], and WANG, M.[3], [1]University of New Hampshire, University of New Hampshire, Durham, NH, 03824, USA; [2]NOAA GLERL, Ann Arbor, MI, USA; [3]NOAA NESDIS, Greenbelt, MD, USA. **Initial results from SeaPRISM measurements in the summer of 2016 in western Lake Erie.**

In the summer of 2016, an above-water multi-spectral autonomous sun photometer called the SeaWiFS Photometer Revision for Incident Surface Measurements (SeaPRISM) was deployed in western Lake Erie for real-time observation of spectral radiance valuable to bio-optical algorithms and satellite validation. This project was an initiative between NOAA NESDIS, NOAA GLERL and the University of New Hampshire. The sensor serves two purposes: 1) as a Cal/Val site supporting remote sensing data product evaluation (e.g., VIIRS) and 2) as an observational system for real-time monitoring of water quality for GLER L's HAB program. The data collected are delivered real-time to the NASA AERONET program. The central feature of a SeaPRISM sun photometer is the continuous measurement of normalized water-leaving radiance (LwN) and atmospheric properties at wavelengths critical for producing water quality products from bio-optical algorithms. The SeaPRISM we deployed in 2016 contained 9 wavelengths used for atmospheric measurements and also matching satellite wavelengths. The SeaPRISM collected data from July 19 to September 9, 2016 and observed a variety of water conditions. We compare these initial results with NOAA's VIIRS measurements over Lake Erie. *Keywords: Observing systems, Lake Erie, Remote sensing.*

MRDJEN, I., KNOBLOCH, T.J., LEE, J., and WEGHORST, C.M., The Ohio State University College of Public Health, 1841 Neil Avenue, Columbus, OH, 43210, USA. **Evaluation of Cyanobacteria and Their Toxins in a Two-Staged Model of Hepatocarcinogenesis.**

Limited epidemiological and preclinical data suggest that ingestion of water contaminated with microcystins and other cyanobacterial toxins may increase rates of liver carcinogenesis. In this pilot study, we hypothesized that chronic exposure of previously initiated liver cells to cyanobacterial toxins in the drinking water would result in cancer promotion. C3H/He male mice were initiated with an i.p. injection of diethylnitrosamine (DEN) followed by oral administration of either i) deionized drinking water (DW); ii) DW with microcystin-LR (MC)(10 μg/L); or iii) DW with lysed cyanobacteria biomass (BM) (100,000 bacteria/L [10 μg/L microcystin-LR equivalent beginning 1 week after DEN injection and continuing for 31 weeks. There was no significant difference in the number of gross liver tumors in DEN+MC or DEN+BM mice compared to DEN+DW mice. However, tumor incidence in DEN+MC mice was significantly reduced (P=0.05) compared to DEN+DW mice. Histopathologic evaluation reveals the % of malignant tumors was significantly higher in the DEN+MC (44%; p=0.02) and DEN+BM (56%; p=0.0001) groups compared to DEN+DW (13%). These data support a promoting role for cyanotoxins in liver carcinogenesis. *Keywords: Harmful algal blooms, Carcinogenesis, Microcystis, Liver, Toxic substances.*

MUNAWAR, M.[1], FITZPATRICK, M.A.[1], NIBLOCK, H.[1], LORIMER, J.[2], and ROZON, R.[1], [1]Fisheries & Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7S 1A1, CANADA; [2]Aquatic Ecosystem Health & Management Society, Burlington, ON, CANADA. **The structure and function of algal blooms in the Bay of Quinte, 2010-2011.**

The occurrence of algal blooms in the eutrophic Bay of Quinte is frequent. Fisheries & Oceans Canada conducted 3 comprehensive surveys of phytoplankton biomass, composition and size-fractionated primary productivity at 12-15 sites in the summers of 2010 (Aug, Sept) and 2011 (Sept). Blooms were not uni-algal but instead composed of a mixture of species of Diatomeae, Cyanophyta and other taxa. 6 - 10 blooms were observed during each of the 3 surveys and exhibited considerable variability. Diatomeae blooms were comprised mainly of *Aulacoseira ambigua, A. granulata* and *Stephanodiscus agassizensis*. Cyanophyta blooms consisted of large number of toxigenic species (22) with the highest number belonging to *Anabaena* (6) and *Microcystis* (5). Using P/B quotients, our results showed that colonial *Microcystis* blooms had a reduced photosynthetic efficiency (P/B=4.7) compared to filamentous blooms of *Aulacoseira* (9), *Gloeotrichia* (13) and *Dolichospermum* (9). These findings challenge the conventional notion of an algal bloom and highlight the need for detailed investigations to characterize the structure and function of algal blooms. *Keywords: Lake Ontario, Biodiversity, Area of Concern, Eutrophication, Phytoplankton.*

MUSHINSKI, M.[1] and ZACHARDA, N.[2], [1]Brown County Land & Water Conservation Dept., 1150 Bellevue St., Green Bay, WI, 54302, USA; [2]Great Lakes Commission, 2805 Industrial Hwy, Suite 100, Ann Arbor, MI, 48104, USA. **Demonstrating Innovation in Wisconsin's Lower Fox River Watershed.**

Since its inception in 2014, the Lower Fox Demonstration Farms Network has succeeded in promoting the adoption of conservation practices that allow local farmers to play an increasing role in reducing nutrients and sediments from farm runoff that drains into tributaries to the Lower Fox River and Bay of Green Bay while also improving soil health and producers' "bottomline." The project is funded by the GLRI through Wisconsin NRCS and administered by the Great Lakes Commission in partnership with both NRCS and the Brown County Land and Water Conservation Department. The initial suite of four participating farmers was expanded in 2016 to include two additional farms as interest continues to build among the local agricultural community. Primarily focused on the promotion of cover crops, including interseeding technologies, the project team is broadening its interests to include advanced manure-management techniques in this dairy-dominated watershed. Members of the project team will share methods, anecdotes, and advice on lessons learned in engaging with the agricultural community and maximizing impact through local partnerships. *Keywords: Nutrients, Agriculture, Watersheds, Sediment transport.*

MUZZI, R.W.[1], RUBERG, S.A.[1], BEADLE, K.S.[1], CONSTANT, S.A.[1], DAVIS, T.W.[1], JOHENGEN, T.H.[1], LUCIER, H.M.[2], and VERHAMME, E.M.[3], [1]NOAA/GLERL, 4840 South State Road, Ann Arbor, MI, 48108, USA; [2]University of Michigan/CILER, 440 Church Street - G110 Dana, Ann Arbor, MI, 48109, USA; [3]LimnoTech, 501 Avis Drive #1, Ann Arbor, MI, 48108, USA. **Observations of the distribution of phytoplankton during cyanobacteria blooms using an AVP.**

An autonomous vertical profiling system (AVPS), integrated into the NOAA GLERL Real-time Coastal Observation Network (ReCON), was deployed for 12 days in August during the 2016 field season. The AVPS was programmed to collect observations of temperature, chlorophyll, and dissolved oxygen at six depth levels from surface to bottom. AVPS data were transferred and solar-battery power was supplied through a short cable connected to the structure-mounted ReCON system. An embedded Linux processor provided sensor data processing, AVPS control, and remote diagnostics during the deployment period. This initial deployment of the AVPS provided insight into the water column vertical distribution of cyanobacteria under variable wave conditions. Project results are being used to provide information about harmful algal bloom (HAB) vertical distribution to water intake managers and to improve NOAA GLERL mixing models. *Keywords: Algae, Lake Erie, Observing systems.*

MYCHEK-LONDER, J.G.[1], DIANA, J.S.[2], CHRISCINSKE, M.A.[3], ROGERS, M.W.[4], KEELER, K.M.[3], STOTT, W.[3], PUCHALA, E.A.[5], and BUNNELL, D.B.[3], [1]Great Lakes Institute For Environmental Research at The University Of Windsor, 401 Sunset Ave, Windsor, ON, n9b1e1, USA; [2]University of Michigan School of Natural Resources and Environment, 440 Church Street, Ann Arbor, MI, 48109, USA; [3]USGS Great Lakes Science Center, 1451 Green Rd, Ann Arbor, MI, 48105, USA; [4]Tennessee Cooperative Fishery Research Unit, PO Box 5114, Cookeville, TN, 38505, USA; [5]University of Vermont, Rubenstein Ecosystem Science Laboratory, 3 College Street, Burlington, VT, 05401, USA. **Diet overlap, egg predation, digestion and recruits among deep offshore benthic Lake Michigan fishes.**

Non native species such as Round Goby and dreissenid mussels and declines in native Diporeia spp. have impacted the offshore Laurentian Great Lakes. We evaluated if

diet overlap between Slimy Sculpin, Deepwater Sculpin, and Round Goby occurred and if egg predation upon natives was apparent. We sampled Lake Michigan fishes from 69-128m at 3-4 locations in Jan-May 2009 and 2010. Important prey (dry weight proportion; percent occurrence) for Slimies were Mysis (0.34; 45%), Diporeia (0.16; 34%), and Limnocalanus macrurus (0.22; 68%) and for Deepwaters were Mysis (0.74; 92%) and Diporeia (0.16; 54%). Goby mainly ate dreissenids (0.68; 95%) and Mysis (0.15; 37%). Both sculpins consumed Bloater (Coregonus hoyi) eggs (Slimy: 0.04, 11%; Deepwater: 0.02, 7%) and ate Deepwater Sculpin eggs (Slimy: 0.03, 13%; Deepwater: 0.05, 16%) during February-May at all sites. Goby consumed fish eggs but minimally (<<0.01, <<1%). Overlap was low among sculpin spp. and very low among goby and sculpin spp. We subsequently determined lab based bioenergetics measures for sculpins through controlled feeding experiments. Lastly we used egg predation and bioenergetics data to re-evaluate and improve a recruitment model for Bloater. Three papers resulted for publication. I will review these and my corresponding experiences as a mentee with James Diana. *Keywords: Fish management, Slimy and deepwater sculpin, Invasive species, DNA Barcoding, Diets, Round goby.*

MYERS, J.A., MCCARTHY, M.J., and NEWELL, S.E., Wright State University, 3640 Colonel Glenn Hwy, Dayton, OH, 45435, USA. **Effects of Nitrogen Loading on Denitrification and Nitrous Oxide Production in a Coastal Wetland.**

Wetlands are productive ecosystems capable of sequestering nitrogen (N) and phosphorus (P) through microbial transformations and assimilation. Wetlands remove excess N (N sink) via denitrification (microbial reduction of NO_3^- to N_2). However, denitrification also forms N_2O, a potent greenhouse gas (GHG). To investigate nutrient removal and N_2O production, intact sediment cores were incubated in 2016 from Old Woman Creek (OWC; Ohio) for analysis of sediment nutrient and dissolved gas fluxes. We hypothesized that (1) denitrification, not anammox, is the primary N removal pathway; (2) denitrification rates are higher in spring and decrease in summer as substrates are depleted; and (3) N_2O production increases with N additions. Preliminary results suggest that OWC sediments are a N source in spring (net N fixation) but a N sink in summer (denitrification). Denitrification rates were stimulated by nitrate additions in spring and summer and sediments at the wetland inlet and outlet were a N_2O source in spring and increased with N additions at the inlet. These data suggest that more denitrification and N_2O measurements in coastal wetlands are needed to determine tradeoffs between nutrient removal and GHG production. *Keywords: Nutrients, Wetlands, Climate change.*

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NAGUSKY, B.N., Lake Erie Energy Development Corp., 1938 Euclid Ave Suite 200, Cleveland, OH, 44115, USA. **Building a Clean Energy Industry based on Sound Science in Lake Erie.**

Icebreaker WIndpower Inc. is turning a decade old vision of a vibrant offshore wind industry in the Great Lakes into a reality. Funded by the U.S. Department of Energy and Fred. Olsen Renewables, Icebreaker Wind is a small demonstration offshore wind farm 8-10 miles off Cleveland's shore. The six turbine 20.7 megawatt wind project will produce enough power for about 7,000 homes. Icebreaker will be the first freshwater offshore wind project in North America. The Project team is working with private consultants and universities to demonstrate that we can build an offshore wind farm in Lake Erie that poses minimal risk to fish and wildlife while helping address the environmental challenges of unhealthy air quality and climate change. A Great Lakes offshore wind industry could create thousands of jobs, help restore local manufacturing, and boost the regional economy. An offshore wind industry in the Great Lakes also would help the region meet its growing energy needs in a sustainable manner. *Keywords: Climate change, Clean Energy Economy, Environmental health, Offshore Wind, Economic impact.*

NAPERALA, T.R.[1] and KROUTH, A.[2], [1]AECOM, 10850 Traverse Highway, Suite 3365, Traverse City, Mi, 49684, USA; [2]Chippewa County Road Commission, 3949 South Mackinac Trail, Sault Ste. Marie, MI, 49783, USA. **Ecological Restoration of the Little Rapids Area of the St. Marys River.**

Since the mid-1800s, the St. Marys River has undergone extensive man-made alterations for the purposes of navigation, travel and hydroelectric power. These changes destroyed habitat at the East and West Neebish Rapids, the Little Rapids, and left only remnants of the Main Rapids. Today, the Main Rapids receives less than 10 percent of its historical flow and represents the only remaining rapids habitat of this globally unique river, however, the Little Rapids is a candidate for restoration. The construction of the causeway, from the ferry dock on Island No. 1 to Sugar Island, destroyed the Little Rapids by diverting flow away from the shallows. Where waters once flowed freely, there is a shallow bay that provides poor habitat for fish and wildlife due to the reduced flows and velocities. With restored flow, however, the area has potential to once again provide foraging, spawning and nursery habitat for a wide variety of sport fish and other aquatic organisms. Restoration of the Little Rapids involve reconnecting the upper and lower sections of the river between Island No. 1 and Sugar Island. The project replaced the existing causeway with a bridge, creating an opening approximately 600 feet wide. This presentation will describe the preliminary engineering, construction and planned monitoring. *Keywords: Coastal engineering, Rapids restoration, Great Lakes Restoration Initiative (GLRI), Ecosystem restoration, St. Louis River AOC, Hydraulic modeling.*

NEGASI ISAAC, B. and DE LOË, R.C., University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L 3G1, CANADA. **Discourse around nutrients problem in western basin of Lake Erie.**

A critical social science perspective is employed to assess governance process in the reduction of nutrient runoff from two watersheds in the western basin of Lake Erie: The Thames and the Maumee. A modified social-ecological systems framework is used to identify discourse (dominant narrative) of various actors regarding the nature of and solutions to the nutrient problem as well as key institutions that affect the achievement of reduction targets. Interview data and document analysis show that, with some overlap, two discourses feature prominently especially on what needs to be done regarding the nutrient problem that has been the main cause of eutrophication in Lake Erie: (1) a technocratic discourse of curbing (including reclaiming) phosphorus runoffs through technological and economic instruments reminiscent of the ecological modernisation approach to environmental protection, and (2) a 'soft approaches' discourse that focuses on behavioural/value change by farmers, rethinking the current structure of the agro-industry, and addressing the upstream-downstream disconnect. The implications of such divergent discourses among actor groups for the effectiveness of the 20% nutrient load reduction target by 2020 from 2008 levels by the province of Ontario and the state of Ohio are analysed, compared and explained. *Keywords: Environmental policy, Nutrients, Lake Erie.*

NELSON, E.J.H.[1], HOLDEN, J.[2], EVES, R.[3], and TUFTS, B.[1], [1]Freshwater Fisheries Conservation Lab, Queen's University, 116 Barrie Street, Kingston, ON, K7L3N6, CANADA; [2]Glenora Fisheries Station, OMNRF, Picton, ON, K0K2T0, CANADA; [3]Protein Function Discovery Lab, Queen's University, 18 Stuart Street, Kingston, ON, K7L3N6, CANADA. **Comparison of Diets for Largemouth and Smallmouth Bass in Eastern Lake Ontario using DNA Barcoding.**

Cargo ships bound for cities located by the Great Lakes have introduced numerous ecologically disruptive species in recent history. The invasion of the Round Goby (*Neogobius melanostomus*) into the Great Lakes has changed several facets of predatory fish biology. Largemouth (LMB: *Micropterus salmoides*) and Smallmouth Bass (SMB: *Micropterus dolomieu*) are two important species in the recreational fisheries of the Great Lakes. Prior studies show that bass have incorporated Round Goby into their diets, but have been limited by low visual identification rates of dissected stomach items. Within the present study, DNA barcoding

and high-throughput strategies provide a more quantitative dietary analysis of adult black bass in Lake Ontario, and compare the importance of Round Goby as prey between these species. Eighty-four LMB and two hundred sixty-four SMB obtained as tournament mortalities had prey identified using DNA based methods. Round Goby was the most prevalent prey species for both predators. The diet of LMB was three times more diverse than that of SMB, which almost entirely consists of Round Goby. Our results provide further support that recent increases in the size of Lake Ontario bass are a result of Round Goby consumption, and that the effects of this dietary shift on body condition are greater for SMB. *Keywords: Fish diets, DNA barcoding, Micropterus, Lake Ontario.*

NETTESHEIM, T.G.[1], YERUBANDI, R.[2], HINCHEY, E.K.[1], ADAMS, J.M.[1], WARREN, G.J.[1], and STADLER-SALT, N.[2], [1]U.S. EPA Great Lakes National Program Office, 77 W. Jackson Blvd, G-17J, Chicago, IL, 60604, USA; [2]Environment and Climate Change Canada, 867 Lakeshore Road, Burlington, ON, L7S 1A1, CANADA. **Lake Superior 2016 CSMI Field Year Overview.**

The binational Cooperative Science and Monitoring Initiative (CSMI) under Annex 10 (Science Annex) of the Great Lakes Water Quality Agreement coordinates agency science and monitoring in support of management of the Great Lakes ecosystem. The process includes enhanced monitoring and science-based field activities which are conducted in one Great Lake per year, tied to the information needs identified by the Lake Partnerships. The 2016 Lake Superior CSMI investigations by federal agencies and partners addressed key knowledge gaps in: assessment of environmental conditions in areas of potential habitat disruption in the Lake Superior Basin; the status of the lower food web; status of benthic and pelagic fish communities; and development of a lakewide index for Lake Sturgeon rehabilitation progress. This presentation will provide an overview of the CSMI five-year cycle that involves the development of science priorities, field year planning, intensive field year science and monitoring, analysis and reporting to decision-makers. Highlights from the Lake Superior 2016 CSMI field year will also be shared. *Keywords: GLWQA, CSMI.*

NEUBAUER, A.K.[1], TEPAS, K.M.[1], and SINGLETON, N.N.[2], [1]Illinois-Indiana Sea Grant, 200 S. Wacker Dr., 19th floor, Chicago, IL, 60606, USA; [2]USEPA Great Lakes National Program Office, 77 W. Jackson Blvd., G-17, Chicago, IL, 60604, USA. **Tweeting at Sea: Bringing Science and Life on a Research Vessel Back to Shore.**

What is as long as 5 school buses, weighs as much as 6 blue whales, and travels a distance roughly equal to half earth's equator in a span of 6 months? The answer, it turns out, is a fantastic hook for talking about research taking place on the Great Lakes. The remarkable work done on board the R/V Lake Guardian is being shared on Twitter for a growing audience of Great Lakes enthusiasts throughout the sampling season. Learn how our outreach efforts are leveraging the "wow" factor of field work on this large research vessel. Specifically, using Twitter to communicate the importance of the Great Lakes and increase awareness of efforts to monitor and protect this incredible natural resource. Presenters will share successful methods for planning and preparing posts that generated a lot of engagement, as well as those that fell flat. Walk away with a better understanding of how to use Twitter along with a few handy online tools to create quick and powerful messages. Get the most out of your 140 characters! *Keywords: Outreach, Social media, Environmental education, Education.*

NEUMANN, A.[1], KIM, D.K.[1], ALLERTON, M.[1], YANG, C.[1], CHENG, V.[1], RICHARDS, A.[2], and ARHONDITSIS, G.B.[1], [1]University of Toronto, Military Trail, Scarborough, ON, CANADA; [2]Environment Canada, Burlington, CANADA. **Probabilistic Assessment of Nutrient Export with SPARROW Model under Extreme Climate Regimes.**

The Lake Simcoe restoration depends on the attainment of phosphorus (P) loading goal of 44 t/y by 2045 which considers P reduction from treatment plants and tributaries. Taking into account a definite success in curbing mostly static point-source loading, the role of stochastic and diffuse non-point sources invites further investigation as exacerbated by two dynamic factors: population growth and intrinsic climate variability. Additionally the recently adopted P Zero Export policy requires all new development projects to undergo P export budget analysis based on land-use specific export coefficients (EC). The current study validates the previous EC estimates by applying SPARROW watershed model across all tributaries in Lake Simcoe, Nottawasaga and Grey Sauble catchments. The novel feature of SPARROW application is the Bayesian hierarchical formulation of model parameters for wet and dry years. The updated rates of nutrient export for urban, agricultural and forested areas corroborated a distinct and disproportionally strong signature of urban runoff on tributary water quality across all catchments for both dry and wet years. This project formulated a long-term monitoring and decision-making tool which identified priority management areas according to differential nutrient export under extreme precipitation regimes.
Keywords: Environmental policy, Adaptive management, Risks, Watershed model, Assessments, Georgian Bay and Lake Simcoe.

NEUVILLE, K.P.[1], SUCHOCKI, C.R.[1], STETTNISCH, M.N.[1], SALO, M.[1], BOCKWOLDT, K.A.[1], and MAAS, M.[2], [1]University of Wisconsin-Milwaukee School of Freshwater Sciences, 600 E Greenfield Ave, Milwaukee, WI, 53204, USA; [2]COBACH, Bacalar, QR, MEXICO. **Fecal Coliform Contamination along Laguna Bacalar Mexico, January 2017.**

Laguna Bacalar is Mexico's second largest freshwater lake located in the state of Quintana Roo. An oligotrophic lake known for its natural beauty, characteristic "seven colors", and perhaps the world's largest assemblage of freshwater stromatolites, it is increasingly attracting visitors and supporting a growing tourism economy. Inadequate sewage treatment infrastructure in the small community of Bacalar results in less than 5% of the total households being connected to a centralized sewage system. This is compounded by reliance on septic systems perched on the underlying karst geology, with very thin to little surface soils and highly porous limestone bedrock. Water quality is a growing concern, but no routine monitoring for fecal coliform or other water quality parameters has been established. Here we report a series of analyses along the shore in the most popular and heavily used recreational areas for swimming, boating and other water sports. The majority of samples collected exceeded accepted standards for fecal coliform abundance, and points to the need for a more rigorous, routine monitoring system. Local community groups are seeking to implement such a program, and are looking for solutions to expanding development and sewage treatment. *Keywords: Microbiological studies, Laguna Bacalar, Mexico, Water quality, Impared water use.*

NEVERS, M.B.[1], BYAPPANAHALLI, M.N.[1], JACKSON, P.R.[2], and BUSZKA, P.M.[3], [1]U.S. Geological Survey, Great Lakes Science Center, 1574 N 300 East, Chesterton, IN, 46304, USA; [2]U.S. Geological Survey, Illinois Water Science Center, 405 N. Goodwin Ave, Urbana, IL, 61801, USA; [3]U.S. Geological Survey, Indiana-Kentucky Water Science Center, 957 Lakeside Boulevard, Indianapolis, IN, 46278, USA. **Tracking Contaminants, Delisting BUIs, and Restoring Ecosystem Services: Grand Calumet River AOC.**

Impairment of Great Lakes Areas of Concern is complex and pervasive, and large-scale restoration can eliminate multiple beneficial use impairments (BUI). In the interim, smaller-scale management efforts can address individual BUIs or resource use. We evaluated efforts to delist the beach closings BUI in the Grand Calumet River (GCR) where closings exceed 15% (Hammond, Whihala) and are as high as 70% of the time (Jeorse). In 2015, water samples collected at beaches and GCR were analyzed for E. coli and molecular contamination markers: human (Bacteroides HF183, Methanobrevibacter nifH), gull (Gull-2), and dog (DogBact). Chemical, physical, and weather conditions and Cladophora algae were measured. Also, a month-long study was conducted at Jeorse using dogs to deter gulls. Results indicated multiple sources: gull, dog, and human markers were present at all locations; correlatives with markers included E. coli concentration, turbidity, and wave height. Gull deterrence decreased E. coli and Gull2 marker; numbers rebounded with program completion. Primary contamination sources were gulls and dogs, and periodic presence of sewage indicated GCR influence. Large-scale restoration efforts should improve overall ecosystem health, but short-term, local management can be used to reduce beach closings and restore ecosystem services. *Keywords: Ecosystem health, Great Lakes Restoration Initiative (GLRI), Management.*

NEWSTED, J.L.[1], SMITH-EDWARDS, S.[1], LINK, J.[1], MARTIN, P.[2], LETCHER, R.J.[3], and BURSIAN, S.[1], [1]Michigan State University, Department of Animal Science, East Lansing, MI, 48823, USA; [2]Environment Canada, Centre for Inland Waters, Burlington, ON, L7S 1A1, USA; [3]Environment Canada, Wildlife & Landscape Sciences, Ottowa, ON, K1A 0H3, USA. **Effects of bis(2,4,6-tribromophenoxy)ethane (BTBPE) in Mink (Mustela vison).**

Brominated flame retardants (BFRs) found in a variety of consumer products have also been observed in the environment, wildlife and humans has prompted concern for these emerging contaminants. As older BFRs have been removed from production and use of non-PBDE BFR alternatives, such as 1,2-bis(2,4,6-tribromophenoxy) ethane (BTBPE) have increased, however little is known about the potential risk it may pose to wildlife. To address this data gap, a dietary reproduction study with adult female mink exposed to 0, 0.014, 0.13 or 2.3 mg BTBPE/kg feed was conducted. Exposure to BTBPE had no significant effect on any adult female physiological or histological endpoints. Likewise, no significant effects were noted in kit or juvenile mink survival, growth or other physiological and histological endpoints. BTBPE was detected predominately in the feces with lesser concentrations in adipose tissue, liver and lung but at concentrations less than dietary concentrations. The results from this study were used to derive toxicity reference values BTBPE and were then compared to concentrations found in Great Lakes biota as well as biota from other locations. The results from this analysis as will be discussed along with an evaluation of the uncertainties associated with this risk evaluation. *Keywords: Environmental contaminants, Wildlife, Risk assessment, PBTs.*

NGHIEM, S.V.[1], LESHKEVICH, G.[2], and JACKSON, C.[3], [1]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA, 91109, USA; [2]2NOAA/Great Lakes Environmental Research Laboratory, 4840 South State Road, Ann Arbor, MI, 48108, USA; [3]NOAA/NESDIS/STAR, 5830 University Research Court, College Park, MD, 20740, USA. **Great Lakes Satellite SAR Ice Type Classification and Its Relation to ICECON.**

This presentation describes the evolution of our freshwater ice identification and classification algorithms and their relation to the U.S. Coast Guard ice severity index, ICECON. The high resolution of satellite synthetic aperture radar (SAR) measurements with its all-weather, day/night sensing capabilities make it well suited to operationally map and monitor Great Lakes ice cover. Using our measured library of calibrated fully polarimetric SAR ice backscatter signatures, an algorithm was developed to classify and map major Great Lakes ice types. Although initial algorithm validation showed that the algorithm could classify ice types in the library, open water was often misclassified owing to the ambiguity encountered in single polarization data due to variations in wind speed and wind direction over water. Further research revealed that multi-polarization backscatter data would be used to map ice and open water without this ambiguity, after which the library of signatures could be applied to classify the ice types. To improve ice classification and to fit into the ICECON ice categories, ice types were grouped into five categories based on minimum and maximum backscatter values. This enabled classification of ice categories relevant to various ICECON levels and assigning ice thickness ranges to the categories. *Keywords: Remote sensing, Ice, Satellite technology.*

NIBLOCK, H.[1], MUNAWAR, M.[1], FITZPATRICK, M.A.[1], LORIMER, J.[2], and ROZON, R.[1], [1]Fisheries and Oceans Canada GLLFAS, 867 Lakeshore Rd, Burlington, ON, L7S 1A1, CANADA; [2]Aquatic Ecosystem Health and Management Societ, Burlington, ON, CANADA. **Assessment of ciliate communities in the eutrophic Bay of Quinte, 2000-2015.**

The Bay of Quinte is a large, shallow embayment of Lake Ontario designated as an Area of Concern for eutrophication issues. A study of the microbial food web was initiated in 2000 complementing the long term assessment of phytoplankton and zooplankton that started in 1973. 180 samples were collected during the growing season (May to October) from 2000-2015. While other microbial parameters (heterotrophic nanoflagellate, autotrophic picoplankton, and bacteria) were measured, the focus of this poster will be on changes in ciliate biomass, community diversity and feeding behaviour. Community biomass was dominated by oligotrichs (Strobilidium, Strombidium and Halteria), and haptorians. Tintinnid and prostome (Balanion, Urotricha) biomass was low. An increase in overall biomass was observed around 2007 and has remained high through 2015. The increase in biomass was mostly haptorians and Strobilidium. Total abundance followed a similar pattern to biomass. Ciliates are a diverse group of protozoa ranging in size and method of feeding. Micro grazers, macro grazers, raptorial feeders and those that prey on flagellates are all found in the Bay of Quinte. An attempt to understand the relationship between ciliates and other planktonic parameters will be undertaken. *Keywords: Bay of Quinte, Ciliates, Ecosystems, Food chains.*

NICHOLAS, J.R., nicholas-h2o, Lansing, MI, USA. **Water Use of Thermoelectric Power Production in the Great Lakes-St. Lawrence River Basin.**

Water withdrawals for thermoelectric power production constitute about 70 percent of withdrawals in the Great-Lakes-St. Lawrence River Basin. Consumptive use associated with these withdrawals, although much less, still accounts for about 22 percent of Basin consumptive use. In recent years, many thermoelectric power plants have been retired and, from 2011-2015, consumptive use for power generation declined 21 percent. The region's states and provinces will be considering these changes in the context of the cumulative impact assessment that they will complete by 2018 under the "Great Lakes Compact" and Agreement. The states and provinces are also beginning to look at additional changes in water use that are expected from the continued retirement of thermoelectric power plants in the Basin. For example, from 2016-2025, twenty planned plant retirements are projected to reduce consumptive use another 18 percent. This presentation will discuss and analyze these recent trends and future projections. *Keywords: Planning, Demand forecast, Power generation.*

NIEMAN, C.N., MCELWAIN, C., and GRAY, S.M., The Ohio State University, School of Environment and Natural Resources, 2021 Coffey Road, 210 Kottman Hall, Columbus, OH, 43210, USA. **Visual Ecology of Lake Erie Fish: Assessing the Impacts of Increased Turbidity on Vision.**

Changes to the visual environment from increased turbidity are expected to result in disrupted visual ecology and are hypothesized to lead to community-level shifts in the Lake Erie ecosystem; the proximate mechanisms underlying such shifts remain to be investigated. Our objective was to determine the effects of elevated turbidity on visual ecology of native Lake Erie fishes. Turbidity influences visual abilities differently within and across trophic levels (e.g. planktivores vs. piscivores) and across different types of turbidity (e.g. algal vs. sedimentary). We therefore analyzed whether increased turbidity results in reduced detection thresholds and decreased visual acuity in two Lake Erie fishes, a forage fish, Emerald Shiner (*Notropis atherinoides*), and a top predator, Walleye (*Sander vitreus*). Utilizing the optokinetic response, we found visual sensitivity in Emerald Shiner (n=12) was higher in sedimentary turbidity (mean=72.4 NTU) than in algal turbidity (mean=32.9 NTU). Preliminary analysis of reaction distance experiments that test visual acuity suggest Emerald Shiner (n=30) and Walleye (n=9) display decreased reaction distance in turbid relative to clear water treatments. Our study provides evidence for decreased visual thresholds and acuity as mechanisms behind fish responses to increased turbidity. *Keywords: Lake Erie, Fish, Turbidity, Vision.*

NIEWINSKI, D.N., BOEDECKER, A.R., MCCARTHY, M.J., and NEWELL, S.E., Wright State University, 3640 Colonel Glenn Hwy, Dayton, OH, 45435, USA. **Quantification of the *nosZ* gene relative to sediment denitrification rates in Lake Erie.**

Lake Erie is the most productive of the Laurentian Great Lakes, and the western basin experiences annual harmful algal blooms. These blooms are controlled by nutrient inputs into the system, such as nitrogen and phosphorus. Denitrification in sediments is a natural sink for excess nitrogen loads, with intermediates including nitrous oxide, a potent greenhouse gas. The nitrous oxide reductase gene (*nosZ*) mediates the conversion of nitrous oxide to dinitrogen gas. This project will quantify the *nosZ* gene in western basin sediments. DNA and RNA were extracted from sediments, and PCR products were cloned to make qPCR standards using the Quantitect SYBR Green Master Mix. We expect that *nosZ* abundance and expression will relate to denitrification rates measured in sediments and that abundance and expression of *nosZ* will also change seasonally, with higher gene expression in the spring than late summer and fall, when nutrients are more likely to limit productivity and organic matter decomposition. We also expect a decrease in *nosZ* abundance with distance from nutrient inputs from the Maumee and Detroit Rivers. This study will support conclusions from parallel geochemical rate measurements and clarify controls on greenhouse gas consumption through denitrification in this eutrophic system. *Keywords: Biogeochemistry, Microbiological studies, Lake Erie.*

NINER, M.R.[1] and STEPIEN, C.A.[2], [1]University of Toledo, Dept. Env. Sci, W. Bancroft St., Toledo, OH, 43606, USA; [2]NOAA PMEL, 7600 Sand Point Way NE, Seattle, WA, 98115, USA. **Genetic and Geographic History of VHS Fish Virus in the Great Lakes.**

A novel strain (IVb) of Viral Hemorrhagic Septicemia virus (VHSv) appeared in the Great Lakes in 2005-6, killing ~32 fish species in large outbreaks. Since 2009, VHS largely went "underground". Our laboratory discerned several new genotypes after the initial outbreaks, showing a "quasi-species" evolutionary "cloud" of variants. We identified and quantified new VHSv genotypes in a 2012 largemouth bass and freshwater drum from western Lake Erie, which lacked classical symptoms and differed from each other. This new investigation surveyed 37 Great Lakes' sites in 2015 and 2016, resampling original outbreak areas and testing 2561 individuals of 55 fish species with our high-resolution diagnostic Start-PCR assay. Just 7 species and 21 individuals were positive (Lakes Erie and Michigan); all lacked clinical disease signs and only 4 were above the minimum detection cell culture level. All 2012-16 isolates genetically differ from the original genotypes, which appear extirpated, indicating that fish populations became largely immune to the original genotypes, while the virus has been evolving to persist at low levels. Our findings suggest that rapid evolution of VHS opens the possibility for continued threats to aquaculture and to naïve fish populations, along with future resurgence in acclimated populations. *Keywords: Fish diseases, Biomonitoring, Invasive species, Virus, Biological invasions, Pathogen.*

NOEL, J.[1], HALL, B.[2], STOECKER, L.[2], GRONEWOLD, A.D.[3], FRY, L.M.[4], SEGLENIEKS, F.[5], and FORTIN, V.[6], [1]National Oceanic and Atmospheric Administration Ohio River Forecast Center, Wilmington, OH, 45177, USA; [2]Midwest Regional Climate Center, Champaign, IL, USA; [3]National Oceanic and Atmospheric Administration Great Lakes Environmental Research Laboratory, Ann Arbor, MI, USA; [4]USACE Detriot District, Great Lakes Hydraulics and Hydrology Office, Detroit, MI, USA; [5]Environment and Climate Change Canada Boundary Waters Issues Unit, Burlington, ON, CANADA; [6]Environment Canada Meteorological Research Division, Dorval, QC, CANADA. **New Website Supporting Bi-national Coordination of Precipitation over the Great Lakes.**

The Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data has been using coordinated gauge only precipitation estimates over the Great Lakes as the primary means for determining annual precipitation for many years. With the advancement in estimation techniques both in remote sensing and gages, improved estimates of precipitation over the Great Lakes are possible to better compute the annual water budget cycle. Since 2012, there has been a movement to bring the latest estimation techniques into use in the Great Lakes. While the gauge only method currently remains the method used to determine the final dataset, the advanced datasets are now available in real-time. Work has focused on seamlessly combining these advanced precipitation datasets available from the United States (Multi-sensor Precipitation Estimates (MPE) generated at NWS River Forecast Centers) and Canada (Canadian Precipitation Analysis (CaPA) provided by Environment and Climate Change Canada). Datasets will be merged and hosted online at the USA Midwest Regional Climate Center (MRCC). The merged product will be MPE over U.S. land areas, CaPA over Canada land areas and an averaged MPE/CaPA product over Great Lakes water areas. The website is expected to come on-line in 2017 and capabilities will be shown.
Keywords: Water Balance, Precipitation.

NORWOOD, G.J., Detroit River International Wildlife Refuge, 9311 Groh Rd., Grosse Ile, MI, 48138, USA. **Linking Applied Research and Management at Detroit River International Wildlife Refuge.**

The Detroit River International Wildlife Refuge is 2,197 acres of natural areas, including another 3,910 acres cooperatively managed with partner organizations, all within Michigan's Lake Erie coastal area. The natural areas are diverse; coastal wetlands, wetland impoundments, former agricultural fields, forest, and even a former industrial brownfield exist within urban, suburban and rural landscapes. Applied research and monitoring on invasive species management are ongoing; ecological inventories are a major emphasis at this time with the intent of ensuring unique local and regional features are not unintentionally lost in well-intentioned restoration work. Inventories can be ongoing and take advantage of

the broad range of interests and skills available in citizen scientists and from local universities. Over 85% of stewardship time is spent managing impoundment infrastructure and Phragmites control, necessitating more applied research on these issues to help optimize the use of existing resources to achieve the multiple objectives established in the Refuge's Habitat Management Plan. *Keywords: Wetlands, Citizen science, Public participation.*

NORWOOD, G.J.[1] and MAY, C.A.[2], [1]Detroit River International Wildlife Refuge, 9311 Groh Rd., Grosse Ile, MI, 48138, USA; [2]The Nature Conservancy in Michigan, 101 E. Grand River, Lansing, MI, 48906, USA. **Costs and Benefits of Phragmites Management in Western Lake Erie Coastal Wetlands.**

The Detroit River-Western Lake Erie Cooperative Weed Management Area is comprised of sixteen organizations in Wayne and Monroe Counties collaborating on invasive plant management. Since 2011, $745,689 of federal and state grants have contributed to Phragmites control on 800 acres of coastal wetland systems along Lake Erie, including two years of early detection of new species. Areas received multiple herbicide treatments via helicopter, mowing, prescribed fire, and now include annual follow-up applications via a shared Marsh Master®. The current model including staff, equipment maintenance, and contracts annually costs just over $100,000 for early detection and herbicide treatments across about 10,000 acres. We use a management objective for Phragmites of not more than 10% total area in emergent and wet meadow zones. Monitoring of representative coastal wetland sites has shown multiple marsh communities changing from significantly above to under the 10% objective. Populations of Sagittaria montevidensis, a state-threatened species, were absent prior to management but were present in four management units in 2016. Current distribution of problematic plant populations are presented, including water lettuce (Pistia stratiotes) and European frog's-bit (Hydrocharis morsus-ranae) which are likely to spread. *Keywords: Phragmites australis, Coastal wetlands, Lake Erie.*

NOWICKI, C.J.[1], ARMENIO, P.M.[2], BUNNELL, D.B.[2], WARNER, D.[2], and MAYER, C.M.[1], [1]U.S. Geological Survey - Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105, USA; [2]University of Toledo - Lake Erie Center, 6200 Bayshore Road, Oregon, OH, 43616, USA. **Comparing niche space overlap and trophic shifts between Lakes Michigan and Huron.**

Lakes Michigan and Huron have experienced increasing oligotrophication in recent years. Crustacean zooplankton and benthic biomass have also declined in both lakes, mostly due to loss of cladocerans and *Diporeia*. Relatively speaking, Lake Michigan has higher TP, dreissenid biomass, and alewife than Lake Huron. To explore whether these food-web differences could cause changes in the trophic structure of these two lakes, we compared

stable isotopes during spring, summer, and autumn in Lake Michigan in 2010 and Lake Huron in 2012 to determine differences in community niche space, niche space overlap, and change of niche space selection by individual species. The two lakes did not differ in $\delta^{15}N$ or $\delta^{13}C$ range, but Lake Michigan had a smaller total niche area. Lake Michigan fish also had a greater probability of niche overlap. Comparison of seasonal niche changes showed that some species decreased in trophic position but niche space selection for the community remained the same in Lake Michigan compared to Huron in spring. In the summer and autumn, the community in Lake Huron acquired more of its energy from nearshore sources and maintained a lower trophic position. The community in Lake Michigan has greater overlap, which could increase competition for resources compared to Lake Huron.
Keywords: Stable isotopes, Lake Michigan, Niches, Lake Huron, Trophic level.

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O'MALLEY, B.P. and STOCKWELL, J.D., Rubenstein Ecosystem Science Laboratory, 3 College Street, Burlington, VT, 05401, USA. **Is diel vertical migration in Mysis related to body size?**

Many populations of migratory animals exhibit behavioral variability at the individual level. In the Great Lakes, the opossum shrimp, *Mysis diluviana*, undergoes extensive diel vertical migration (DVM), linking offshore benthic and pelagic communities. The general model of *Mysis* DVM assumes individuals are benthic by day and pelagic by night. Previous benthic investigations, however, have also reported some *Mysis* remain benthic at night (non-migrants). Whether non-migrants are different from migrants or just a random subsample of the total population remains unclear. We compared *Mysis* benthic-pelagic distributions and demographics day vs. night in Lake Champlain across June-November from two sites (60 and 100m) in 2015. Benthic *Mysis* were sampled via benthic sled tows, and pelagic *Mysis* were sampled with a vertically towed net. Contrary to expectations of DVM, no difference in benthic CPUE day vs. night was evident at both sites. Pelagic CPUE did not differ between day and night at 100m, but was significantly higher at night than day at the 60-m site. Benthic individuals had higher mean body length and consisted of older life stages than pelagic-caught individuals. Our findings suggest divergent *Mysis* DVM behavior may be related to body-size in Lake Champlain. *Keywords: Zoobenthos, Mysis, Plankton, DVM, Lake Champlain.*

O'MEARA, J.[1], LOVALL, S.[2], BURNS, R.L.[2], BAILEY, A.[1], BLICHARSKI, T.[2], BOOTE, M.[1], and BOHLING, M.E.[3], [1]Environmental Consulting & Technology, Inc., 2200

Commonwealth Blvd., Suite 300, Ann Arbor, MI, 48188, USA; [2]Friends of the Detroit River, 20600 Eureka Rd., Suite 313, Taylor, MI, 48180, USA; [3]Michigan Sea Grant Extension, Detroit, MI, USA. **Stony and Celeron Islands - Major Implementation of Habitat in the Detroit AOC Under GLRI.**

GLRI has sped up progress in the Detroit River AOC including habitat restoration around two islands. The Stony and Celeron Island Projects will directly address three BUIs: loss of fish and wildlife habitat, degradation of fish and wildlife populations and degradation of benthos within the Detroit River AOC. Both islands have the capacity to provide tremendous fish, spawning habitat and nursery grounds and the island's complex association of emergent, shrub and palustrine and wetland habitats has been home to many wildlife species. The area had historically been a very productive spot for rare and transient waterfowl. The restoration will prevent continued degradation of remaining habitat, allow for recovery of areas that have seen loss, and stimulate expansion of quality habitat. Significant positive recreational impacts are also anticipated. The ecological outcomes specific to removing the fish and wildlife BUIs are: re-establishment of spawning and nursery habitat, revitalization of coastal wetlands and, protection of terrestrial resources. Construction completed with GLRI funds, includes: 6,000 lft of habitat shoals, 75 acres of backwater habitat restored and protected, 250 habitat structures, and 1500 lft of nesting barrier beach. Prior to GLRI, projects like these were rare in the AOC due to lack of funding. *Keywords: Detroit River, Coastal ecosystems, Fish.*

O'REILLY, K.E., University of Notre Dame, Department of Biological Sciences, 292 Galvin Life Sciences Center (Hank Wing), Notre Dame, IN, 46556, USA. **It's Beginning to Look a Lot Like #25DaysofFishmas: #Scicomm through Education and Entertainment.**

A major goal in science communication (#scicomm) is producing a personal response towards science, often one or more of the following: awareness, enjoyment, interest, opinion-forming, and understanding (the "AEIOU" model, Burns et al. 2003). Using an example hashtag campaign, #25DaysofFishmas, I illustrate how Twitter can create opportunities for scientists, particularly graduate students, to communicate science to diverse audiences and produce personal responses towards Great Lakes environmental issues. I created the Twitter hashtag #25DaysofFishmas to profile a different Great Lakes fish species for each day in December 2016. #25DaysofFishmas combined ecology, history, culture, and humor to successfully engage a diverse audience from across the world in learning more about the native and introduced fish species that inhabit the Laurentian Great Lakes. By involving scientists, agencies, and the public, this exercise in science communication became a community effort with individuals contributing articles, photos, and anecdotes. Social media, particularly Twitter, is not simply a tool for scientists to broadcast their research to diverse audiences, but also a platform to engage and affect personal responses towards science. *Keywords: Public participation, Public education, Outreach.*

OLDFIELD, L.E., WU, M., and ROBINSON, C., Western University, 1151 Richmond St, London, ON, N6A 3K7, CANADA. **Geospatial model Estimating Phosphorus Loadings from Septic Systems to the Lake Erie Basin.**

The relative importance of septic systems as a source of phosphorus (P) to the Great Lakes and their tributaries is not well quantified. The lack of quantitative estimates of P loading from septic systems to surface waters is due in part to the limited tools available to reliably estimate P loading at a watershed or basin wide scale, as well as the complexity of the source. To address the uncertainty regarding septic system P loading, a comprehensive review of geochemical and hydrologic conditions controlling P mobility from subsurface septic system environments to surface waters was conducted. This review was used to inform the development of a geospatial model to quantify P loading from septic systems into surface waters for conditions relevant to the Lake Erie Basin. Using ArcGIS, the model simulates the movement of P to surface waters from septic systems. Preliminary results from a pilot test of two sub-watersheds in the Lake Erie basin indicate that septic systems P loadings may be a significant source of the annual loadings into the lake. This model will be used to improve estimates of P loadings in the Lake Erie basin, and furthermore, to better inform management decisions regarding P loading from septic systems. *Keywords: GIS, Modeling, Harmful algal blooms, Lake Erie.*

ORLANDO, S.A.[1], LUCENTE, J.E.[1], TOMAN, E.[2], HEEREN, A.[2], and WALPOLE, E.G.[2], [1]Ohio Sea Grant College Program, 1314 Kinnear Road, Area 100, Columbus, OH, 43210, USA; [2]The Ohio State University, School of Environment and Natural Resources, 316C Kottman Hall, 2021 Coffey Road, Columbus, OH, 43210, USA. **Do Your PART: A Coastal Storms Preparation, Adaptation, and Response Tool for Great Lakes Marinas.**

The damage inflicted by Superstorm Sandy in 2012 caused many marina managers in the Great Lakes to become concerned about the vulnerability of their marinas to coastal storms. Ohio Sea Grant pursued and obtained a National Oceanic and Atmospheric Administration Coastal Storms Grant in partnership with the OSU School of Environment and Natural Resources, along with Pennsylvania and Wisconsin Sea Grant, in 2014. The grant project, *Development of a Coastal Storm Preparation, Adaptation, and Response Tool for Great Lakes Marinas*, aimed to understand the needs, drivers and barriers to preparing for extreme weather hazards and to then develop tools that will help marina owners now and in the

future. Focus groups with marina owners in Erie, Pennsylvania, Cleveland, Ohio, and Milwaukee, Wisconsin were completed to engage the marina community and conduct a needs assessment with the user group. Drawing on this data, the project team developed a tool, the *PART*, to address concerns raised in focus groups and support climate adaptation and coastal resiliency decisions of marina owners/operators. Results of the focus groups will be shared as well as the tool and accompanying outreach materials. *Keywords: Outreach, Resiliency, Water level fluctuations, Shore protection.*

OSANTOWSKI, E.S., WARREN, G.J., and NETTESHEIM, T.G., United States Environmental Protection Agency/ Great Lakes National Program Office, 77 W Jackson Blvd, Chicago, IL, 60604-3511, USA. **Analysis of long-term water quality trends across open waters of the Great Lakes from 1983.**

In accordance with the Great Lakes Water Quality Agreement, the U.S. EPA Great Lakes National Program Office (GLNPO) has monitored a wide range of water quality parameters within the open waters of the Great Lakes annually since the mid-1980s. GLNPO used nonparametric statistical methods to identify significant trends in and potential drivers of water quality across the lakes in data from 1983. The observed trends across multiple parameters (turbidity, dissolved reactive silica, total phosphorus, and total dissolved phosphorus) point towards a shift in trophic state among the Great Lakes. Lake Superior is showing signs of increased productivity and increased trophic state, while the other lakes are showing signs of decreasing trophic state and movement towards oligotrophic conditions. These trophic shifts appear to be in response to changing pollutant loadings, and to internal biogeochemical cycling related to the introduction and establishment of invasive zebra and quagga mussels (dreissenids) in the 1990s. Trends in specific conductivity and total chloride suggest that the upper Great Lakes are responding more slowly to these changes, whereas the lower Great Lakes are responding more quickly and exhibit changes only due to more recent influences. These trends agree with those found in data from Environment Canada. *Keywords: Invasive species, Monitoring, Nutrients.*

OUDSEMA, M.E.[1], HASSETT, M.C.[1], STEINMAN, A.D.[1], and OUDSEMA, M.E.[2], [1]Grand Valley State University Annis Water Resources Institute, 740 West Shoreline Drive, Muskegon, MI, 49441, USA; [2]Cooperative Institute for Limnology and Ecosystems Research (CILER), 4840 S. State Rd., Ann Arbor, MI, 48108, USA. **Long-Term Monitoring of Phosphorus in a Grassroots Initiative to Improve and Restore a Watershed.**

Lake Macatawa (Lake Mac), located in southwest Michigan, is the receiving water body for a highly degraded watershed and has exhibited the symptoms of a hypereutrophic lake for over 40 years. Because of excess phosphorus (P) enrichment, the lake and all of its

tributaries are included on Michigan's 303(d) list of impaired water bodies, prompting the issuance of a P Total Maximum Daily Load (TMDL) of 50 µg/L in Lake Mac (mean 2016 TP concentration = 92 µg/L). Project Clarity is a large-scale, multidisciplinary, collaborative, public-private partnership whose overarching goal is to restore the water quality in Lake Mac and its surrounding watershed. To this end, a long-term monitoring initiative was developed to provide critical information on the performance of two key wetland restoration areas and the overall status of Lake Mac. Restoration of the floodplain wetland projects was recently completed in 2015, so upstream-downstream P reductions are not yet evident; however, TP concentrations increased above 3000 µg/L (~63x the TMDL) during storm events, indicating the potential value of increasing retention and assimilation in these floodplains. Recent improvements in average TP concentrations in Lake Mac from historical averages, which are likely a function of natural variation, may have created unrealistic expectations. *Keywords: Monitoring, Remediation, Phosphorus.*

OUYANG, W.[1], ROWE, M.D.[2], and ZHANG, H.[2], [1]School of Natural Resources and Environment, University of Michigan, Dana Building 440 Church Street, Ann Arbor, MI, 48108, USA; [2]Cooperative Institute for Limnology and Ecosystems Research, University of Michigan, G110 Dana Building 440 Church Street, Ann Arbor, MI, 48108, USA. **Skill Assessment of the Lake Erie HAB Tracker Forecast Model using Variable Spatial Neighborhoods.**

Forecasts of harmful algal bloom (HAB) spatial distribution are useful to public water systems, anglers, and recreational boaters. The Lake Erie HAB Tracker model is initialized from satellite-derived HAB spatial distribution, then uses a hydrodynamic forecast to predict the transport and vertical distribution of HABs in Lake Erie over a 5-day period. The model was assessed previously using pixel-by-pixel skill statistics; however, such statistics produce large penalties for small spatial mismatch between simulated and observed fields. Here, we used an alternative approach, fractions skill score (FSS), which has been used in precipitation forecast skill assessment. FSS assesses model skills over a series of increasing spatial neighborhood sizes. Model skill may improve with increasing neighborhood size if spatial mismatch between simulated and observed fields is a problem. We calculated FSS for a series of 26 hindcast simulations from 2011. We compared model skill to a benchmark persistence forecast, which assumed no change from the initial satellite image. Model skill exceeded that of the persistence forecast initially, but the advantage decreased at day 7. Model skill was greatest at 1 km neighborhood size for days 1-2, but improved at neighborhood size of 3-5 km for days 3-6, a period when the forecast is more challenging. *Keywords: Harmful algal blooms, Forecast skill assessment, Modeling, Spatial neighborhood size, Lake Erie.*

OWEN, J.M.[1], HILLIS, E.L.[1], CHAGANTI, S.R.[1], STAMMLER, K.L.[2], and HAFFNER, G.D.[1], [1]GLIER- University of Windsor, 2990 Riverside Drive, West, Windsor, ON, N9C 1A2, CANADA; [2]Essex Region Conservation Authority- ERCA, 360 Fairview Avenue West, Suite 311, Essex, ON, N8M 1Y6, CANADA. **Harmful Algal Blooms (HABs) in Lake Erie and Possible Causes of a Low Bloom Year (2016).**

Harmful algal blooms (HABs) have caused many water quality problems in Lake Erie. In 1972, the Great Lakes Water Quality Act (GLWQA) was implemented to help alleviate these problems. However, HABs started to return to Lake Erie in the 1990s, and were dominated by toxic cyanobacteria, particularly *Microcystis* . It is thought that rainfall and nutrients from spring runoff affect the size and toxicity of HABs. This hypothesis was supported in 2016, when April - July rainfall was lower than historical averages, and there were no reports of HABs present in the Western Basin in the summer months. To further examine this link between nutrients and HABs, water samples were taken at four different sites located in the western basin of Lake Erie in 2016. Microscopic techniques and DNA analysis confirmed the presence of *Microcystis* ; however, concentrations were lower than in previous years. The highest *Microcystis* concentrations were found near Pelee Island in August and September, similar to previous years. Surface concentrations were also higher than at lower depths. Concentrations of soluble reactive phosphorus, total phosphorus, and nitrate will also be analyzed to see how they relate to *Microcystis* . This information will provide further insight into the drivers of HABs for low bloom years. *Keywords: Eutrophication, Algae, Lake Erie.*

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PAERL, H.W.[1], GARDNER, W.S.[2], MCCARTHY, M.J.[3], NEWELL, S.E.[3], XU, H.[4], ZHU, G.W.[4], QIN, B.[4], OTTEN, T.G.[5], SCOTT, J.T.[6], HAVENS, K.E.[7], WURTSBAUGH, W.A.[8], HALL, N.S.[1], ROSSIGNOL, K.L.[1], and WILHELM, S.W.[9], [1]UNC-Chapel Hill, Institute of Marine Sciences, 3431 Arendell Street, Morehead City, NC, 28557, USA; [2]Univ. of Texas, Marine Science Institute, Port Aransas, TX, 78373, USA; [3]Wright State Univ. Dept. of Earth and Atmospheric Sciences, Dayton, OH, 45435, USA; [4]Nanjing Institute of Geography & Limnology, Chinese Academy of Sciences, Nanjing, 210008, CHINA; [5]Bend Genetics LLC, Sacramento, CA, 95825, USA; [6]Baylor University, Dept. of Biology, Waco, TX, 76798, USA; [7]University of Florida Institute of Food and Agricultural Sciences, Gainesville, FL, 32608, USA; [8]Utah State University, Watershed Sciences Department and the Ecology Center, Logan, UT, 84322-5210, USA; [9]University of Tennessee, Dept. of Microbiology, Knoxville, TN, 37996-0845, USA. **Controlling cyanobacterial blooms in "great" lakes: Dual (N & P) nutrient reductions are needed.**

Globally, lakes are experiencing proliferation of harmful cyanobacterial blooms (CyanoHABs). CyanoHAB control has focused on reducing phosphorus (P) inputs, assuming that nitrogen (N2) fixation supplies sufficient ecosystem N needs. However, nutrient enrichment studies indicate that CyanoHABs flourish in response to combined N and P, more so than N or P alone. This pattern is exacerbated by climatic changes, including warming, more extreme storms, and droughts. The toxic CyanoHAB Microcystis often dominates in these conditions. Microcystis cannot fix atmospheric N2 and requires dissolved inorganic or organic N sources to support growth. Microcystis blooms proliferate worldwide despite decades of P loading controls in the Great Lakes and other basins. Fertilizers, urban and agricultural wastes, and atmospheric deposition increase inputs of bioavailable N. Unlike P, N occurs in gaseous forms and is lost to the atmosphere as N2 via denitrification and other N sinks, perpetuating N-limitation. In-system N2 fixation may not compensate for overall N loss in productive lakes with high denitrification rates. Thus, external N inputs and internal N recycling drive eutrophication and CyanoHABs. The P-only management paradigm should be broadened to incorporate cases where external N input reductions are required to control blooms. *Keywords: Eutrophication, Phosphorus, Nutrients, Nitrogen, Cyanophyta, Blooms.*

PALAGAMA, D.S.W., MARVIN, R.K., WEST, R.E., and ISAILOVIC, D., University of Toledo, 2801 W. Bancroft St., Department of Chemistry and Biochemistry, University of Toledo, Toledo, OH, 43606, USA. **Developing methods for preconcentration and LC-MS quantification of microcystins in water and serum.**

Microcystins (MCs) are often released into lake water during harmful algal blooms. They cause public concern due to their acute toxicity and chronic effects on humans and wildlife. US EPA advises that the total MC concentration in drinking water should be ≤ 0.3 μg/L (ppb). Therefore, accurate and reproducible techniques are needed to detect sub-ppb concentrations of MCs in water and biological samples. Here, the separation and accurate quantification of six common microcystins at sub-ppb concentration levels in MC-spiked water are described. Limits of quantification for each MC were further improved by the development of a reproducible solid-phase extraction (SPE) protocol for microcystin purification and preconcentration. This protocol facilitated LC-MS quantification of MCs at ppt (ng/L) or sub-ppt levels in tap water, river water, and lake water. Developed methodologies were also applied for high-throughput quantitative LC-MS analyses of microcystins in water samples obtained from the collaborators at the University of Toledo. The results indicate that methods developed allow sensitive, selective, and reproducible quantification of MCs in water samples. Currently, these methods are being optimized to preconcentrate MCs in spiked serum in order to enable quantification of MCs in biological specimens, such as blood. *Keywords: Water quality, Harmful algal blooms, Toxic substances.*

PALMER, C.J.[1], BLUME, L.J.[2], FEVOLD, B.F.[1], WALTERS, L.W.[1], LEWIS, T.[3], STAPANIAN, M.A.[4], and MIDDLEBROOK AMOS, M.[1], [1]CSRA, 6361 Walker Lane, Suite 300, Alexandria, VA, 22310, USA; [2]US EPA Great Lakes National Program Office, 77 W Jackson Blvd, Chicago, IL, 60604, USA; [3]US Army Corps of Engineers, 3909 Halls Ferry Road, Vicksburg, MS, 39180, USA; [4]U.S. Geological Survey, 6100 Columbus Ave., Sandusky, OH, 44870, USA. **Quality Control Field Checks to Improve Project Quality for Aquatic Habitat Restoration.**

Habitat restoration requires the collection of reliable data for determining the appropriateness of planning and techniques, evaluating the effectiveness of restoration activities, and building the necessary evidence to support management decisions. Quality control (QC) checks provide the empirical data necessary for these tasks. We describe the use and application of QC checks to improve data quality (reliability, integrity, and objectivity) in ecological restoration projects, focusing on projects associated with the Great Lakes Restoration Initiative. In particular, we describe how "hot" checks, "cold" checks, "blind" checks, "calibration" checks, and "precision checks" are used for evaluating the quality of restoration data and assessing success of restoration projects. We describe how all types of data collected in restoration projects, including those collected with calibrated instruments and by best professional judgment, are subject to rigorous assessments of precision and accuracy. *Keywords: Habitats, Ecosystems, Environmental effects.*

PANNUNZIO, G. and SANDERS, C., Detroit River Canadian Cleanup, Suite 311, 360 Fairview Avenue West, Essex, ON, N8M1Y6, CANADA. **Ongoing remediation within the Detroit River shows improvements while restoring beneficial uses.**

Issues facing the Detroit River include combined sewer overflows, urbanization, degradation of habitat, and toxic contaminants causing beneficial use impairments. Some major remedial action accomplishments were the removal of PCB-contaminated soil in Turkey Creek, the improvement to effluents to secondary treatment Windsor and the near-elimination of combined sewer overflows from a major sewershed in the City of Windsor. Furthermore, the creation of fish and wildlife habitat through various shoreline naturalization projects and Lake Sturgeon spawning reef contributed to restoring several beneficial uses. These initiatives as well as efforts of the Detroit River Canadian Cleanup to outreach to the public have raised the profile of the Detroit River in the community. This session will describe the unique story of remediation that requires coordination and engagement with multiple organizations, establishing partnerships, participating in ongoing monitoring and connecting the progress back to the Detroit River stakeholders. The presenters will share lessons learned and an update to remedial action items slated for the next few years for the Canadian side of the Detroit River. *Keywords: Habitats, Improvements, Remediation, Partnerships, Detroit River, Lessons Learned.*

PARKER, J.N.[1], AHMED, A.[2], MONSHI, M.[2], REDDY, N.[2], KASHIAN, D.R.[1], MCELMURRY, S.P.[3], and PITTS, D.K.[2], [1]Biological Sciences, Wayne State University, 2125 Biological Sciences Building, Detroit, MI, 48202, USA; [2]Dept Pharmaceutical Sciences, Wayne State University, 259 Mack Ave, Detroit, MI, 480202, USA; [3]Civil and Environmental Engineering, Wayne State University, 2100 Engineering Building, Detroit, MI, 48202, USA. **Imidacloprid, a neonicotinoid: Physiological, behavioral, community level effects on Daphnia pulex.**

Imidacloprid (IMI), a neonicotinoid insecticide, is one of the most widely used insecticides in the world. It is found in surface water and is considered a contaminant of emerging concern. IMI has been implicated in bee colony collapse disorder. 6-chloronicotinic acid (6-CNA) is a photodegredation product of IMI, and very little is known about its toxicity. This study examined the effects of IMI and 6-CNA on a non-target species, *Daphnia pulex*, an aquatic freshwater crustacean and keystone species. The effects of these chemicals on *D. pulex* were examined at the physiological and behavioral level, and in a simple community comprised of predator (*Hyrda littoralis*) and prey (*D. pulex*). The hypothesis was that similar concentrations of IMI can affect *D. pulex* at three biological levels: physiological, behavioral and in a simple community. 6-CNA did not have significant effects on physiology or behavior at 250 μM. Imidacloprid had significant acute effects (1 hr) on appendage beat rate (ABR), heart rate (HR), swimming behavior (24 hrs), and affected the susceptibility of *D. pulex* to predation by H. littoralis(24 hrs) in the concentration range of 16 to 256 μM. These results suggest that short-term exposure to neonicotinoids can affect behavior and community-level interactions of D. pulex. *Keywords: Crustaceans, Environmental contaminants, Pesticides.*

PARVIZIAN, B.A., FERNANDO, S., HOLSEN, T.M., and CRIMMINS, B.S., Clarkson University, 8 Clarkson Ave., Potsdam, NY, 13699, USA. **Determining Hexaboromocyclododecane and Tetrabromobisphenol concentration in fish tissues using LC-H.**

Hexaboromocyclododecane (HBCD) and Tetrabromobisphenol A (TBBPA) are brominated flame retardants (BFRs) that are commonly used as part of building insulation and in many common household items. The annual production volume of these BFRs exceeds 100,000 tons per year since 1998. Due to the toxic and persistent nature of these compounds multiple regulatory agencies have started to monitor there levels in the environment and food. Therefore, as a part of Great Lakes Fish Monitoring and Surveillance Program (GLFMSP), an analytical method for measuring the concentration of three HBCD isomers and TBBPA in fish tissues has been developed. Different extraction techniques were evaluated prior to analysis of the samples using liquid chromatography coupled to high resolution mass spectroscopy (LC-HRMS). Using the optimized method HBCD and TBBPA levels of fish from multiple Lakes and years will be determined to establish geographical and temporal trends. *Keywords: Fish, BFR, Mass spectrometry, LC/HRMS.*

PASHNIK, L., SMITH, M., STOTT, W., and RILEY, S., Great Lakes Science Center USGS, 1451 Green Rd., Ann Arbor, MI, 48105, USA. **Historical Stocking of Lake Whitefish and Cisco in the Great Lakes Region.**

Coregonids are important components to the Great Lakes ecosystem and food web. Historically coregonids, including cisco, *Coregonus artedi* and lake whitefish, *C. clupeaformis*, were the targets of large commercial fisheries. Both species have suffered population declines as a result of over-fishing and habitat loss. As a result, cisco have disappeared from Lake Erie and abundance has declined in other lakes and lake whitefish populations were reduced. Cisco have become the target of restoration efforts which include habitat restoration, changes to harvest regulations, and stocking. Information on past stocking programs can be useful to help understand factors that influence the success of present day stocking efforts. To this end, we reviewed historical records from the 1870's to the 1930's from the US Fish Commission and summarized the geographic distribution of coregonid stocking events over that time. During this period, cisco and lake whitefish from Lake Erie and the Detroit River were stocked in the Great Lakes, inland lakes in Great Lakes states and beyond, and in other countries. *Keywords: Detroit River, Stocking, Lake Erie, Coregonids.*

PATERSON, G.[1], MCLEOD, A.M.[2], DROUILLARD, K.G.[3], and HAFFNER, G.D.[3], [1]Michigan Technological University, 1400 Townsend Drive, Houghton, MI, 49931-2718, USA; [2]Memorial University of Newfoundland, St. John's, NL, A1C 5S7, CANADA; [3]Great Lakes Institute for Environmental Research, University of Windsor, Windsor, ON, N9B 3P4, CANADA. **Ecological tracers indicate basin specific ecologies for the Lake Huron food web.**

Lake Huron has experienced substantial ecological change and little is known of how these have manifested across the lake's three basins. Here, we quantified stable isotope, persistent organic pollutant (POP) and mercury concentrations in multiple trophic levels from Lake Huron's North Channel, Georgian Bay and Main Basins to compare and contrast food web structure as depicted by stable isotopes and mercury and POP profiles as potential indicators of energy consumption and assimilation efficiencies. Stable isotopes suggest similar trophic structure and energy flow pathways among the three basins with POP bioaccumulation profiles demonstrating high degrees of basin fidelity among Lake Huron lake trout. However, POP biomagnification and Hg bioaccumulation patterns suggest differing efficiencies of energy transfer and lake trout bioenergetics among the basins. Contrasting pollutant bioaccumulation profiles were also observed in rainbow smelt and bloater suggesting that ecological stressor effects are manifested in multiple trophic levels but to different extents across the basins. These results indicate different ecological responses within Lake Huron with the North Channel being potentially the least affected by stressor effects followed by the Main Basin and Georgian Bay. *Keywords: Stable isotopes, Pollutants, Lake Huron.*

PAUER, J.J.[1], BROWN, T.N.[1], MELENDEZ, W.[2], LOWE, L.L.[3], and HOLLENHORST, T.P.[1], [1]USEPA, 6201 Congdon Blvd, Duluth, MN, 55804, USA; [2]CSRA, Duluth, MN, 55804, USA; [3]Leidos, Durham, NC, 27709, USA. **Great Lakes nearshore assessment: What would Goldilocks do?**

Concerns with the nearshore water quality of the Great Lakes, such as excessive eutrophication and harmful algal blooms, called for establishing a nearshore monitoring program to gain a better understanding of the watershed-nearshore link. This is challenging, as sporadic runoff events and varying current direction cause the nearshore to be very dynamic and exhibit large spatial and temporal gradients. A comprehensive picture of nearshore water quality using field observations alone would necessitate a prohibitively extensive monitoring network to be designed. Instead, a hybrid approach using moderate monitoring complemented by coastal modeling could be utilized. Existing models range from simplistic models to highly complex formulations of the biogeochemistry and transport evaluated over a fine-scale computational grid. Our approach is to complement field observations with two simple models: a nested transport model with simple nutrient kinetics, and a zero-dimensional eutrophication model with sophisticated kinetic formulations. Although both models have strengths and weaknesses, our results indicate that this hybrid approach has several advantages over either a monitoring only program, or a complicated model with a monitoring program, to efficiently address nearshore water quality and to manage this precious water resource. *Keywords: Eutrophication, Modeling, Coastal ecosystems.*

PAUFVE, M.R.[1], SETHI, S.A.[1], LANTRY, B.F.[2], JONAS, J.L.[3], O'NEILL, P.[3], CHIODO, A.[4], BERGLUND, E.K.[4], YULE, D.L.[5], FURGAL, S.[6], WEIDEL, B.C.[2], and RUDSTAM, L.G.[7], [1]New York Cooperative Fish and Wildlife Research Unit, 211 Fernow Hall, Cornell

University, Ithaca, NY, 14853, USA; [2]USGS Lake Ontario Biological Station, 17 Lake St, Oswego, NY, 13126, USA; [3]Charlevoix Fisheries Research Station, 96 Grant Street, Charlevoix, MI, 49720, USA; [4]Ontario Ministry of Natural Resources and Forestry Upper Great Lakes Management Unit, 435 James Street South, Suite 221e, Thunder Bay, ON, P7E6S7, CANADA; [5]USGS Lake Superior Biological Station, 2800 Lake Shore Dr, East Ashland, WI, 54806, USA; [6]State University of New York College of Environmental Science and Forestry, 1 Forestry Dr, Syracuse, NY, 13210, USA; [7]Cornell Biological Field Station, 900 Shackelton Point Rd, Bridgeport, NY, 13030, USA. **Investigating Habitat Suitability for Cisco (*Coregonus artedi*) Spawning and Egg Incubation.**

Cisco (*Coregonus artedi*) are shallow-water coregonines that were historically abundant in the Great Lakes, important prey for native piscivores, and the target of large commercial fisheries. In response to fishing pressure and interactions with nonnative species, populations began to decline in the late 1800s and losses continued through the mid-1900s. This resulted in Cisco currently being scarce or extirpated in some Great Lakes systems. Restoration projects have recently been initiated with the goals of increasing abundance and encouraging the use of historical spawning locations in the Great Lakes. Information on Cisco spawning ecology will be useful for prioritizing target areas for stocking juvenile Cisco and monitoring naturally reproducing populations. Towards that end, we are studying documented Cisco spawning sites at a high-energy reef complex in Lake Michigan and a relatively low energy area in Lake Superior to identify habitat variables associated with egg presence and viability. A diaphragm pump is used to collect eggs from the lake bottom and habitat attributes are measured using underwater video cameras and other sensors. High quality Cisco spawning habitat will be characterized by estimating the relationship between habitat attributes and spawning evidence using an occupancy modeling framework.
Keywords: Cisco, Native species restoration, Fisheries.

PAUL MARSHALL, V. and JUDY WESTRICK, A., Wayne State University, Detriot, MI, 48202, USA. **Online Volatile Organic Contaminant Monitoring: Huron to Erie Corridor.**

The Huron to Erie corridor includes the St. Clair River, Lake St. Clair and the Detroit River. Over 7 million people live in this watershed and use the corridor for recreation and drinking water. This bi-national industrial waterway provides cooling and wash water, transportation, and pipeline crossings, making it a thriving location for petroleum refineries, chemical manufacturers, paper mills, salt producers, and electric power plants. Other industrial river utilities use online volatile organic contaminant monitoring as an early warning system. These data have been used to make water management decisions such as: 1) drinking water plant updates; 2) land use development; 3) development of hydrodynamic models; and 4) emergency contingency planning. Our goal was to pilot two online volatile organic contaminant monitoring systems and evaluate the monitoring systems efficiency and sustainability for the drinking water utilities. We installed a THM RR at the Waterworks Park Plant in Detroit and a CSM 5000 at the Marysville Water Plant. Project design, implementation, evaluation, and recommendations will be presented. Understanding the occurrence, distribution and trends of contaminants is important to the people that depend on the Huron to Erie Corridor as a drinking water source and a recreational waterway. *Keywords: Monitoring, Organic compounds, Water quality.*

PAVER, S.F.[1], NEWTON, R.J.[2], and COLEMAN, M.L.[1], [1]University of Chicago, Chicago, IL, USA; [2]University of Wisconsin-Milwaukee, Milwaukee, WI, USA. **Microbial diversity across the Laurentian Great Lakes through space and time.**

Microorganisms are key components of aquatic food webs that respond to and shape lake biogeochemistry. We present results from a survey of Laurentian Great Lakes microbial diversity covering an unprecedented extent: samples collected from 2-3 basins within each lake, 3-4 depths per station, during spring overturn and again in August from 2012 to 2015. Great Lakes microbial assemblages included taxa commonly observed in freshwater lakes (e.g., acI, betI, LD28, Pnec, LD12) as well as novel taxa, including *Ignavibacteriae* and recently described *Chloroflexi*. Microbial communities in the four deep lakes (Superior, Michigan, Huron, Ontario) were strongly structured by depth during summer stratification. Summer surface communities exhibited lake-specific differences, roughly partitioning into two groups: those collected from warmer, more productive lakes Erie and Ontario and those collected from colder, less productive lakes Superior, Michigan, and Huron. Notably, surface communities from a cool lake (Michigan) in a warm year exhibited high similarity to surface communities from a warm lake (Ontario) in a cool year. These observations begin to inform our understanding of how nutrients, temperature, light, and other factors structure microbial communities across the Great Lakes. *Keywords: Microbiological studies, Genetics, Biogeochemistry.*

PAWLOWSKI, M.B.[1], WICK, M.J.[1], BOLGRIEN, D.W.[2], ANGRADI, T.R.[2], NORD, M.[3], HINCHEY, E.K.[4], SCHAROLD, J.V.[2], COTTER, A.[2], PEARSON, M.S.[2], BARTSCH, W.[5], LIETZ, J.E.[6], and CORRY, T.D.[2], [1]Oak Ridge Institute for Science and Education, 6201 Congdon Blvd., Duluth, MN, 55804, USA; [2]U.S. EPA, Mid Continent Ecology Division, 6201 Congdon Blvd., Duluth, MN, 55804, USA; [3]U.S. EPA, Region 5, 77 W. Jackson Blvd., Chicago, IL, 60604, USA; [4]U.S. EPA, Great Lakes National Program Office, 77 W. Jackson Blvd., Chicago, IL, 60604, USA; [5]Natural Resources Research Institute, University of Minnesota Duluth, Duluth, MN, USA; [6]CSRA, Duluth, MN, USA. **Sediment and water quality insights from the Great Lakes connecting channels NCCA surveys.**

Probability-based surveys of the U.S. Great Lakes coastal waters (excluding connecting channels) were conducted in 2010 and 2015 as part of EPA's National Coastal Condition Assessment (NCCA). Research on the Huron-Erie corridor (HEC; 2014, 2015) and the St. Marys River (SMR; 2015, 2016) is continuing in order to include connecting channels in the NCCA. We used existing NCCA sampling protocols, indicators, and assessment thresholds for water and sediment quality to compare conditions in the HEC and SMR to conditions in adjacent lakes. Preliminary results show that water quality in the connecting channels was intermediate (as % area in poor condition) compared to up- and down-stream lakes. Mixed watershed land uses also likely impact water quality in connecting channels. Sediment quality was characterized as good in 49% and 38% of the HEC and St. Marys River (by area), respectively which was similar to the lakes. Rocky substrates, shallow sites, and hard-bottom river channels meant that 2.4-9% of connecting channel area could not be assessed. This was less than the 22-25% unassessed in the lakes. Research goals include piloting an assessment of the Niagara River, and evaluating indicators and assessment thresholds for connecting channels. *Keywords: Water quality, St. Marys River, Sediment quality, Detroit River, St. Clair River.*

PECORARO, S.D.[1], WARNER, D.M.[1], ESSELMAN, P.C.[1], GRUNDEL, R.[1], O'BRIEN, T.P.[1], JUTEAU, J.P.[2], and MANARY, T.W.[2], [1]USGS Great Lakes Science Center, 1574 N 300 East, Chesteron, IN, 46304, USA; [2]Maritime Way Scientific, 1420 Youville Dr, Orléans, ON, K1C 7B3, CANADA. **Bottom-Type Classification of Multi-Year Acoustic Transects across Lakes Michigan and Huron.**

Across the Great Lakes, there is a widespread need to map variation in lake-bottom properties at large spatial scales, but few large scale datasets exist. However, the US Geological Survey possesses ~115,000km^2 of acoustic data from 15 years of fisheries research in lakes Michigan and Huron. In this study, we used that data to classify bottom-type variation using backscatter measurements from two frequencies of split beam sonar returns(120kHz and 38kHz). We compared the covariance of several classification schemes (*k*-means clustering, expectation maximization, random forests), and evaluated their agreement with results from widely used commercial seabed classification software and historic substrate maps. Future efforts should focus on ground-truthing the classification models to assign definitive classes to the unsupervised seabed classifications. Once validated against field data, classifications of split beam data like this one can help inform our regional understanding of bottom-type variation. *Keywords: Acoustics, Bottom sampling, Great Lakes basin.*

PEI, L.[1], HUNTER, T.[2], BOLINGER, R.[1], and GRONEWOLD, A.D.[2], [1]UCAR, Ann Arbor, MI, USA; [2]NOAA (GLERL), Ann Arbor, MI, USA. **Applying Climate Change Projections in Great Lakes Regional Water Management Decisions.**

Over the past several decades, Great Lakes regional hydrological forecasting systems have been developed or modified to propagate future climate change projections into impacts on water supplies, connecting channel flows, and water levels. More recently, General Circulation Models (GCMs) have been applied to provide an indication of future hydrological response over multi-decadal periods. Here, we describe the development and application of a new set of future climate forcings from Phase 5 of the Coupled Model Intercomparison Project (CMIP5). These forcings synthesize results from 19 different CMIP5 models with an emphasis on the RCP4.5 scenario. In addition, our research focuses primarily on hydrologic response over the next 2-3 decades; a time period that is of primary concern to regional water resource management agencies including (but not limited to) hydropower authorities along the Niagara and St. Lawrence Rivers. Before applying the CMIP5 forcings, we corrected their systematic (internal) biases using the quantile delta mapping (QDM) method; an approach aimed at minimizing corruption of future climate signals while recognizing the importance of correctly simulating historical climate patterns. Our results provide a new set of climate-based forcing data for a range of hydrological modeling application *Keywords: Climate change, Hydrologic cycle, Decision making.*

PENNUTO, C.M.[1] and MEHLER, K.[2], [1]Biology Department, Buffalo State College, 1300 Elmwood Avenue, Buffalo, NY, 14222, USA; [2]Great Lakes Center, Buffalo State College, 1300 Elmwood Avenue, Buffalo, NY, 14222, USA. **Nutrient Translocation by Round Gobies: Is it Significant to Lake Ontario Food Webs?**

Nutrient translocation by organisms can be significant in aquatic ecosystems, and is exemplified by salmon bringing marine-derived nutrients into freshwater spawning streams. The round goby may perform equally impressive nutrient transfer activities during annual nearshore-to-offshore migrations. We estimated the population density and size distribution of round gobies in the nearshore of western Lake Ontario and the lower Niagara River, documenting the disappearance of fish from August to December that coincided with temperature reductions. We used published values for annual survival probabilities and average phosphorous content to estimate how much tissue-bound phosphorus potentially was translocated to offshore habitats by the round goby population. Our population of round gobies averaged 4.4 cm TL, had an average mass of 1.01 g, and a mean density of 213,702 fish per hectare. This translated into 1,261 g P per ha locked within goby tissue, or ~41 mT of P in these fish extrapolated to the U.S. nearshore zone (0-10 m zone). This represents about 3% of the total incoming tributary P load to the U.S. nearshore. Assuming

a 54% annual mortality rate, it is possible roughly 20 mT of P is provided to offshore food webs. *Keywords: Biological invasions, Fish behavior, Phosphorus.*

PEREZ-FUENTETAJA, A.[1], CLAPSADL, M.[1], SNYDER, R.J.[2], and COCHRAN, J.[1], [1]Great Lakes Center, SUNY Buffalo State, 1300 Elmwood Ave., Buffalo, NY, 14222, USA; [2]Biology Department, SUNY Buffalo State, 1300 Elmwood Ave., Buffalo, NY, 14222, USA. **Importance of migratory forage fish in the workings of the Niagara ecosystem: the emerald shiner.**

Small forage fish species play important roles in aquatic ecosystems supporting the upper food web. This role is more pronounced in seasonal or migratory forage fish populations that bring in nutrients and biomass to an ecosystem that otherwise might not support large predatory species populations. The emerald shiner (*Notropis atherinoides*) plays such a function in the upper Niagara River, a migratory flyway internationally recognized for its role supporting migration and staging of birds bound for the Arctic as well as diversity of resident fishing birds. A large portion of the emerald shiner population in the river moves to Lake Erie in late summer/autumn and back into the river in late spring. However, a resident population of these fish overwinter in the river, usually comprised of juveniles. In the Niagara, emerald shiners constitute the largest part of the diet of walleye (90%) and steelhead trout (72%) and are the most preferred prey fish of the New York State Threatened common tern (*Sterna hirundo*). The annual abundance of shiners is the major determinant for these birds' nesting success. Therefore, the abundance, condition, growth and caloric content of the emerald shiners in the upper Niagara have important cascading consequences for the fish and avian species that utilize this river. *Keywords: Fish populations, Migrations, Food chains.*

PERREAULT-PAYETTE, A.[1], MUIR, A.[2], GOETZ, F.[3], PERRIER, C.[5], NORMANDEAU, E.[1], SIROIS, P.[4], and BERNATCHEZ, L.[1], [1]Université Laval, 1030 avenus de la Médecine, Quebec, QC, G1V 0A6, CANADA; [2]Great Lakes Fishery Commission, 2100 Commonwealth Boulevard, Suite 100, Ann Arbor, MI, USA; [3]Northwest Fisheries Science Center, 98366 Port Orchard, Washington, WA, USA; [4]Université du Québec à Chicoutimi, Quebec, QC, CANADA; [5]Centre d'Écologie Fonctionnelle et Évolutive, Montpellier, FRANCE. **Parallelism in Morphological and Genomic Divergence among Lake Trout Ecotypes in Lake Superior.**

Lake Trout (*Salvelinus namaycush*) is renowned for the occurrence of different ecotypes linked to resource and habitat use throughout North America. We aimed to unravel the fine genetic structure of the four Lake Trout ecotypes in Lake Superior. A total of 486 individuals from four sites were genotyped at 6822 filtered SNPs using RADseq technology. Our results revealed different extent of morphological and genetic differentiation within the different sites. Overall, genetic differentiation was weak but significant and was on average three times higher between sites than between ecotypes within sites indicating higher level of gene flow or a more recent shared ancestor between ecotypes within each site than between populations of the same ecotype. Evidence of divergent selection was also found between ecotypes and/or in association with morphological variation. Outlier loci found in genes related to lipid metabolism and visual acuity were of particular interest in this context of ecotypic divergence. However, we did not find clear indication of parallelism at the genomic level, despite the presence of phenotypic parallelism among some ecotypes from different sampling sites. *Keywords: Lake trout, Genetics, Lake Superior.*

PETERSON, B.P., OYSERMAN, B., and MCMAHON, K.D., University of Wisconsin - Madison, 1550 Linden Drive, Madison, WI, 53706, USA. **Spatial distribution of acI sub-clades along chemical gradients in Lake Erie.**

The acI lineage of freshwater *Actinobacteria* consists of widely-distributed and small heterotrophic organisms that often dominate bacterial communities. There is a great degree of metabolic diversity within the acI lineage, and their distribution likely plays a significant role in the overall metabolism of freshwater lakes. Sub-groups of acI exhibit seasonal and niche partitioning across lakes. However, the spatial distribution of acI OTUs along nutrient, temperature, and other gradients within a single body of water are less well understood. Lake Erie exhibits a strong chemical gradient due to high anthropogenic inputs to the western basin. Here, we collected bacterial samples spatially distributed across Lake Erie, enriched in acI by size-fractionation, as well as water quality and nutrient data. 16S sequencing provided an overview of the distribution of the various acI lineages along several chemical gradients. Additionally, several sites were chosen for shotgun DNA metagenomic sequencing based on environmental measurements and acI identity to provide insight into the metabolic potential of the acI community at each site. This study provides insight into the influence of environmental conditions on acI partitioning and will guide future studies on the role of discrete acI populations in metabolic cycling in lakes. *Keywords: Microbiological studies, Metabolism, Genetics.*

PETERSON, L.K. and JONES, M.L., Michigan State University, East Lansing, MI, 48824, USA. **Evaluating Mortality Estimation Methods Using Simulated Acoustic Telemetry Data.**

Natural mortality in fish populations tends to be an unobservable phenomenon that is difficult to measure directly. However, it remains a critical component of stock assessment models. Acoustic telemetry has the potential to provide a more direct way for estimating this important rate. International collaborations such as the Great Lakes Acoustic Telemetry

Observation System are generating large amounts of data on a variety of fish species and may be able to provide the information needed for better estimates of survival. The focus of this project was to develop mortality estimation approaches and evaluate them using a simulation framework, using the existing Lake Erie walleye telemetry data as a guide. Two models, one spatial and one non-spatial, were developed to estimate mortality using acoustic detections. Simulated data were generated using an individual based modelling approach. Using this simulation framework, different scenarios including different receiver distributions and different natural mortality rates were evaluated to determine the precision and accuracy of the models under different study designs and assumptions. The results of this work have the potential to inform researchers about appropriate estimation methods as well as strategies for acoustic telemetry study design for determining natural mortality. *Keywords: Lake Erie, Modeling, Acoustics.*

PETRELLA, S.K.[1], SANO, L.L.[2], MULLER, R.D.[1], and KUKULSKI, P.J.[1], [1]Friends of the Rouge, 4901 Evergreen Rd KM, Dearborn, MI, 48128, USA; [2]University of Michigan, 105 S. State St, Ann Arbor, MI, 48109, USA. **Round goby invasion in an urbanized stream associated with rapid changes in benthic fish community.**

Since its introduction into the Saint Clair River in 1990, the round goby (*Neogobius melanostomus*) has spread rapidly into the Great Lakes followed by expansion into Great Lakes tributaries. Benthic fish populations including johnny darter (*Etheostoma nigrum*) and mottled sculpin (*Cottus bairdi*) have declined in areas after round gobies successfully reproduced (Janssen and Jude 2001). Round gobies were first documented in the Rouge River, a tributary of the Detroit River and Lake Erie in southeast Michigan, in 2011. In 2012, the removal of a dam on the Lower branch of the Rouge River allowed the round goby to migrate further upstream. To examine the impact of this invasion, we tracked the upstream migration of the round goby and the fish community response for four years. In the first year, gobies moved 8.3 km upstream followed by an additional 5.6 km over the next three years. The individual round gobies arriving at new upstream locations were significantly larger than the average residing downstream. Johnny darter numbers declined quickly at the invasion front and this decline persisted over the course of the study. These results indicate that the round goby is rapidly changing the fish community mix in the lower Rouge River. *Keywords: Urban watersheds, Round goby, Invasive species.*

PETTITT-WADE, H.[1], MCLEOD, A.M.[2], and HAFFNER, G.D.[1], [1]Great Lakes Institute for Environmental Research, University of Windsor, 401 Sunset Avenue, Windsor, ON, N9B3P4, CANADA; [2]Memorial University of Newfoundland, 230 Elizabeth Ave, St Johns,

Ne, A1B 3X9, CANADA. **Basin Specific Niche Partitioning of Lake Huron Lake Trout.**

Understanding variability in feeding behaviour within large lake systems is a consistent challenge yet crucial for better management of natural resources. Lake Huron is undergoing major fluctuations in food web structure, but the relative response of top predators among basins remains unclear. We examined variation in Lake Trout feeding behaviour within and among basins of Lake Huron using carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) stable isotopes and polychlorinated biphenyl (PCB) congeners within fish tissues. Niche metrics (Bayesian Standard Ellipse Area, Distance to Centroid) were drawn from the bi-plot of two stable isotopes, or two PCB's, and investigated in reference to basin specific demographics. Both within and among variation in niche area, based on SI and PCB tracers, decreased significantly from Main Basin > Georgian Bay > North Channel. Larger size and age range in the Main Basin explained some of the higher niche variation, but smaller niches of North Channel populations were also associated with lower lipid content, which could be due to the energetic demands of foraging on a variety of prey and/or between multiple patches. These findings demonstrate how multiple environmental tracers can provide novel insights on feeding ecology in a heavily impacted system. *Keywords: Lake trout, Fish behavior, Lake Huron, Niches.*

PHILLIPS, K.R.[1], GALAROWICZ, T.L.[1], CLEVENGER, J.[2], and CLAPP, D.F.[2], [1]Central Michigan University, Mount Pleasant, MI, 58859, USA; [2]Michigan Department of Natural Resources, Charlevoix, MI, 49720, USA. **Smallmouth Bass Movement in Northern Lake Michigan, USA.**

Several regions of Lake Michigan support exceptional fisheries for Smallmouth Bass, but very little is known about the large-scale movement patterns of Smallmouth Bass in large open systems. Fishery managers would like to know more about the movements of these populations in order to make informed management decisions. Smallmouth Bass were trapped in three regions of northern Lake Michigan: Grand Traverse Bay, Beaver Island Archipelago and Waugoshance Point. Individual Smallmouth Bass were tagged at each site to determine how Smallmouth Bass move in the northern Lake Michigan regions. Movements were monitored using passive tracking via mark-recapture methods, and the model incorporated distance as a parameter among the three regions. Results indicate there are populations of Smallmouth Bass that move great distances within the northern Lake Michigan, suggesting that Smallmouth Bass of Lake Michigan should be treated as a whole population, not sub-populations like previous regulations. Large proportions of tagged Smallmouth Bass transitioned to Grand Traverse Bay from the Beaver Island Archipelago and Waugoshance Point and populations of the Grand Traverse Bay on average had a higher survival probability. This knowledge can help managers make decisions about management of this important fishery. *Keywords: Fish, Smallmouth, Fish tagging, Movement, Lake Michigan.*

PICKARD, S.W., US Army Corps of Engineers, 1776 Niagara Street, Buffalo, NY, 14207-3199, USA. **Remediation of Sediments in the Ashtabula River Area of Concern (AOC) on Lake Erie.**

Remediation of sediments from Lake Erie's Ashtabula River AOC was accomplished in three main phases using multiple authorities, agencies and federal/non-federal funding sources. The major contaminant of concern driving cleanup was polychlorinated biphenyls (PCBs). Main phases of AOC remediation included 2006-2007 dredging of the Upper River lead by the U.S. Environmental Protection Agency under the Great Lakes Legacy Act (GLLA); 2008 dredging of the Lower River by the U.S. Army Corps of Engineers (USACE) under Operations and Maintenance and the Water Resources Development Act; and final 2013-2014 dredging of remaining areas of the river lead by USACE under the Great Lakes Restoration Initiative and GLLA. The entire remediation removed about 800,000 cubic yards of sediments at a total approximate cost of $86 million. Significant improvements measured in the AOC to date include low PCB residues in sediment and fish. Beneficial use impairments that have been delisted include restrictions on fish and wildlife consumption, degradation of fish and wildlife populations, and loss of fish and wildlife habitat. Overarching lessons learned relate to the development and acceptance of cleanup goals, differing agency authorities and policies regarding sediment PCBs, and implications for long-term management of dredged sediments. *Keywords: Remediation, Area of Concern, Sediments, Ashtabula River, PCBs, Lake Erie.*

PINERO, E., The Pinero Group LLC, 555 Eagles View, Lancaster, PA, 17601, USA. **How Data Can Support the Business Case for Water Stewardship.**

Businesses are becoming increasingly aware of water related risk issues, such as quantity, quality, and impact to watersheds. As a result, there has been much activity in the area of water stewardship. Often, this begins with "inside the fence line" actions such as water use efficiency and reuse. However, the next step involves taking stewardship actions that impact the surrounding watersheds. In order to select priority actions and make the business case for investment in stewardship practices, the organization needs a better quantitative understanding of the nature of the watershed. This requires data on quantity and water balance, quality, and other stresses. To avoid duplication of data collection efforts by multiple companies in the same watershed, an approach for regional data collection by third parties, such as universities, that makes the data available to all would be of great value. A regional effort in the Great Lakes may be the catalyst to encourage more water stewardship activities by area companies. The Water Institute of the Gulf and the work by the Alliance for Water Stewardship will be discussed as examples. *Keywords: Management, Water Stewardship, Decision making, Regional analysis.*

PISKUR, M.S., Conference of Great Lakes and St. Lawrence Governors and Premiers, Chicago, IL, 60606, USA. **A Regional Science Strategy for Water Uses from the Great Lakes-St. Lawrence River Basin.**

The Great Lakes-St. Lawrence Agreement and Compact require eight US states and two Canadian provinces "to provide leadership for the development of a collaborative strategy with other regional partners to strengthen the scientific basis for sound decision making." As part of this strategy, the states and provinces collect annual water use data and report to a regional database. Major improvements have been made in recent years in the availability and quality of data. The states and provinces also assess cumulative water use impacts for the basin every five years. In 2013, the first basin-wide assessment of cumulative water use impacts was completed. The assessment focused on the cumulative impacts of consumptive uses, withdrawals, and diversions relative to the Basin water budget. Interim assessments comparing water use data against the 2013 assessment are completed annually, and the next five-year assessment will be completed by 2018. Additionally, the states and provinces are beginning to project future water use demand from major water use sectors. This presentation will focus on key findings, recommendations, and lessons learned that may be instructive for future work in the region, and that may provide a model for others regions seeking to improve their watershed management. *Keywords: Management, Water use data, Assessments.*

PISKUR, M.S., Conference of Great Lakes and St. Lawrence Governors and Premiers, Chicago, IL, 60606, USA. **Regional Collaboration to Protect the Great Lakes and St. Lawrence River Against AIS.**

Regional collaboration is necessary to act on serious threats from aquatic invasive species (AIS) to the Great Lakes-St. Lawrence basin. Through the Conference of Great Lakes and St. Lawrence Governors and Premiers, the region's chief executives help lead these regional efforts to protect the system from AIS. For example, in 2013, the Governors and Premiers developed a list of the "least wanted" AIS that present a serious threat of invasion. This effort is driving state, provincial, and federal actions to prohibit or otherwise restrict the movement of these species across the region. The success of the "least wanted" list set the stage for the completion of a Mutual Aid Agreement (MAA) among the states and provinces in 2015. The MAA facilitates cooperative response actions and the sharing of staff, expertise and resources if a new AIS threat is detected. The agreement is broadly designed to help prevent the introduction and spread of AIS; foster mutual aid among the states and provinces to respond to serious threats from AIS; and encourage further cooperative actions to combat AIS. This presentation will focus on state and provincial efforts to combat AIS, and opportunities for future collaboration to enhance regional protections. *Keywords: Invasive species, Policy making, Management.*

PITCHER, T.E.[1], LEHNERT, S.[1], HEATH, D.D.[1], LEWIS, J.A.[1], and PETERS, K.[1], [1]Great Lakes Institute for Environmental Research, University of Windsor, 401 Sunset Ave, Windsor, ON, N9B3P4, CANADA; [2]Western University, 1150 Richmond St., London, ON, N9A 3RS, CANADA. **Major histocompatibility complex variation among alternative reproductive tactics of Chinook salmon.**

To investigate genetic diversity in Lake Ontario Chinook salmon, we genotyped males representing two alternative reproductive tactics, jacks (small sneaker males) and hooknoses (large guarding males). We genotyped fish from the population at neutral (microsatellites) and functional (MHC II ß1) markers. Estimates of genetic diversity, including number of alleles, allelic richness and heterozygosity, were greatest for jacks compared to both hooknoses and females at the MHC. Females showed the lowest levels of genetic diversity, where only 50% of the females were heterozygous. Pairwise genetic divergence was calculated between the groups. Jacks and females were significantly genetically divergent, whereas all other pairwise comparisons were not genetically divergent. Genetic diversity estimates from neutral markers were similar among groups, with the exception of number of alleles, likely due to differences in number of individuals genotyped. There was no significant genetic divergence between jacks, hooknoses and females. These results suggest that there are genetic differences between alternative reproductive tactics that ought to be taken into account when examining the genetic make-up of the Lake Ontario population of Chinook salmon. *Keywords: Lake Ontario, Salmon, Genetics.*

POINT, A.D., CRIMMINS, B.S., HOLSEN, T.M., and FERNANDO, S., Clarkson University, 8 Clarkson Ave., Box 5708, Potsdam, NY, 13699, USA. **Perfluoroalkyl Acid Extraction and Quantification Optimization and Basin-Wide Temporal Insights.**

Perfluoroalkyl acids (PFAAs) have been identified and characterized worldwide in environmental media since first discovered in biota in 2001. Ubiquity and amphiphobicity of PFAAs present challenges for extraction and quantification of these compounds. Discoveries made during extraction method development will be outlined including steps to minimize sorption of long-chain PFAAs during sample preparation. An Acquity UPLC equipped with a G2-XS QTof mass spectrometer will be employed to compare sensitivity in MSE (full-scan) and Tof-MRM (selective) acquisition modes with the objective to develop a targeted/non-targeted method with sensitivity comparable to conventional targeted techniques. This will allow PFAA quantification as well as data screening for novel contaminants, while the richness of the Great Lakes Fish Monitoring and Surveillance Program's tissue archive enables over one decade of spatial and temporal concentration trend determination. *Keywords: Environmental contaminants, Fish, Monitoring.*

PONTE CABRAL, S., BORDER, C.T., WRONKO, E.A., BABBITT, C.W., and TYLER, A.C., Rochester Institute of Technology, 85 Lomb Memorial Drive, Rochester, NY, 14618, USA. **Toxicity of engineered carbon nanomaterials in benthic freshwater ecosystems.**

Fullerenes are a class of carbon allotropes with unique properties that make them useful in a variety of applications. This diverse array of applications and derivatives creates the need to understand the environmental implications of engineered carbon nanomaterial (CNM) release. We combine traditional toxicity testing using a model organism and ubiquitous benthic bioturbator, Lumbriculus variegatus, with a microcosm approach to understand the implications of toxicity effects on biogeochemistry and ecosystem function. At high concentrations C60 enhanced benthic ecosystem metabolism and showed small impacts on nitrogen cycling processes in microcosms composed of sediments from Irondequoit Bay, an embayment of Lake Ontario. L. variegatus alone had significant impacts on benthic metabolism and sediment nitrogen release, but these impacts were not substantially influenced by C60. The CNMs C60, C70, and derivative PCBM had minor sublethal impacts on L. variegatus. These experiments illustrate that although engineered CNMs may have an impact on individual organisms and ecosystem processes at high concentrations, at anticipated environmentally relevant concentrations there are few measurable direct or invertebrate-mediated indirect impacts on overall benthic ecosystem function. *Keywords: Ecosystems, Environmental contaminants, Benthos.*

POUDEL, R.[1] and STERNER, R.W.[2], [1]I.M. Systems Group and NOAA, Silver Spring, MD, 20910, USA; [2]University of Minnesota Duluth, Duluth, MN, 55812, USA. **Assessing the Ecosystem Services Provided by Earth's 21 largest lakes.**

The purpose of this study was to create a first high-level overview of several categories of quantifiable ecosystem services provided by the 21 largest freshwater lakes on Earth. Among the ecosystem services, fisheries, water-based transportation, tourism and recreation and several varieties of direct water use were selected, which have direct impacts to humans. All except perhaps one of the the lakes provided quantifiable services in fisheries. About half of the lakes provided quantifiable services in marine freight. Direct water use varied greatly among the lakes and five of the lakes provided hydroelectricity as a

service in their outflows within xx km of the shoreline. Ecosystem services provided by freshwater lakes vary by biophysical conditions, social setting and other factors. We also observed a decay in overall economic activity as distance increases from the shore. Two subset of lakes were analyzed and found that the Great Lakes in North America hold most of the economic value in tourism and recreation (95%), water transport (85%), and water use while African Great Lakes hold in fisheries (92%) of all 21 lakes. *Keywords: Economic evaluation, Ecosystems, Comparison studies.*

PRESS, J. and MILLER, C.J., Wayne State University, 5050 Anthony Wayne Drive, Detroit, MI, 48105, USA. **Lake St. Clair Metropark: Radon Based Computational Mass Balance Approach to SGD Flux Quantification.**

Over the past decade, the recurrence of Submarine Groundwater Discharge (SGD) as a topic of publication has increased greatly. Previous published research which is generally focused on coastal regions or small lakes does not take into consideration the significance of atmospheric evasion of radon (a ubiquitous groundwater tracer) as well as the increased opportunity for rapid dilution and dispersion of groundwater input via SGD when applied to a system as large and shallow as Lake St. Clair and its riverine inputs and outputs. Data collected from the HEART lab at Lake St Clair Metropark indicates that this evasion of radon occurs under non-steady state conditions. The goal of this project is to refine the basis of averaged mass balance end member determination into a discretized system where the accounting of concentration gradients of radon is used as the main tracer of submarine groundwater discharge transport. This project utilizes python and its built-in scientific data processing libraries to transform raw data exported by the RAD7 (alpha ray spectrometer/portable radon detector) into workable data that can be represented by kml processing and graphical representation. The project highlights the significance of the HEART field stations for academic studies and scientific research. *Keywords: Atmosphere-lake interaction, Groundwater, Lake St. Clair, Radioisotopes.*

PRICHARD, C.G.[1], JONAS, J.L.[2], STUDENT, J.J.[3], WATSON, N.M.[1], and PANGLE, K.L.[1], [1]Central Michigan University, Department of Biology, 200 Library Dr, Mount Pleasant, MI, 48859, USA; [2]Michigan Department of Natural Resources, Charlevoix Fisheries Research Station, 96 Grant St, Charlevoix, MI, 49720, USA; [3]Central Michigan University, Department of Earth and Atmospheric Sciences, 200 Library Dr, Mount Pleasant, MI, 48859, USA. **Otolith chemistry patterns within- and between-species of resident sculpin and juvenile salmonids.**

Otolith microchemistry is an increasingly important tool for investigating mixed-stock fisheries. As such, understanding the relatedness of otolith chemistries among species may reveal more efficient strategies for data collection, and support the development of broader and more accurate applications of this technique. We assessed whether the otolith chemistries of non-migratory, river-resident species were related to those of juvenile, migratory species occupying the same habitats. Otolith chemistries of non-migratory sculpin, juvenile steelhead, and juvenile coho salmon were compared among 16 sites across the Lake Michigan basin. For each element measured, we developed interspecific mathematical relationships, and assessed the assignment accuracies of interspecific classification models. To test if chemistries exhibited significant temporal variation, we quantified: 1) the inter-annulus variation of sculpin, ages 2-5, and 2) the inter-year-class variation among juvenile steelhead and coho salmon. This research enhances the utility of otolith chemistry for understanding mixed-stock fishery dynamics in the Great Lakes. *Keywords: Otolith chemistry, Fisheries, Salmon.*

PRIYADARSHINI, M., URBAN, N.R., PERLINGER, J.A., HENDRICKS, A.H., and ALAKAYAK, W., Michigan Technological University, Houghton, MI, 49931, USA. **Factors Affecting Fish Mercury Concentration in Inland Lakes.**

Mercury pollution is an environmental problem that adversely affects ecosystems and human health. Human activities like fossil fuel consumption, waste incineration and mining are responsible for Mercury contamination in the Great Lakes region. Mercury in the form of methyl mercury tends to bioaccumulate in the aquatic ecosystem, thereby affecting the fish, the fish-eating wildlife and humans. Bioaccumulation of methyl mercury may be affected by a wide variety of factors such as watershed area, organic carbon contents of sediments, pH, dissolved oxygen, food chain length, temperature, land cover characteristics, and others. To understand the effects of environmental factors on methyl mercury concentration in fishes, a study was conducted on the walleye in the inland lakes in the Upper Peninsula. Of the 74 lakes for which data were available, 69 had fish mercury concentrations above the values recommended for unlimited fish consumption. Multivariate statistical analyses were used to identify the parameters that affect the concentration of methyl mercury in walleye. Our results show that fish methyl mercury concentrations are best predicted by pH, maximum lake depth, and watershed area: lake area. While further investigation is warranted, this analysis provides a means to predict the lakes that are safest for fish consumption.

PROPS, R.[1], SCHMIDT, M.L.[1], HEYSE, J.[2], VANDERPLOEG, H.A.[3], BOON, N.[2], and DENEF, V.J.[1], [1]Department of Ecology and Evolutionary Biology, University of Michigan, Ann Arbor, MI, 48109, USA; [2]Center for Microbial Ecology and Technology (CMET), Ghent, 9000, BELGIUM; [3]NOAA Great Lakes Environmental Research Laboratory, Ann

Arbor, MI, USA. **Invasive dreissenid mussels induce phenotypic shifts in bacterioplankton communities.**

Recent advances in microbial flow cytometry analysis have allowed the calculation of phenotypic diversity estimates from minute amounts of sample. Here, we validated this approach for high-diversity freshwater environments. We then demonstrated its efficacy in detecting subtle transitions in the phenotypic properties of a natural bacterioplankton community when subjected to feeding pressure by invasive dreissenid mussels. Based on a data set of parallel flow cytometry and 16S rRNA gene amplicon data from various environments, the phenotypic diversity was shown to be highly correlated to the taxonomic diversity. This allowed the application of the phenotypic diversity as the sole metric to infer changes in both the phenotypic and taxonomic diversity. Using the flow cytometry approach, a significant decrease in the diversity (11.6 ± 4.1%) was detected within one hour of feeding. We further demonstrate that this diversity loss was caused by selective feeding of IDMs upon high nucleic acid (HNA) populations at a clearance rate that is comparable to that of laboratory strains. Based on known characteristics of HNA populations this selective behaviour is predicted to directly impact ecosystem function, as it drives the bacterioplankton community towards a less productive and less diverse state.
Keywords: Microbiological studies, Flow cytometry, Dreissena, Lake Michigan.

Q

QIAN, S.S.[1] and STOW, C.A.[2], [1]The University of Toledo, Department of Environmental Siences, 2801 W. Bancroft Street, Toledo, OH, 43606, USA; [2]NOAA-GLERL, 4840 South State Rd, Ann Arbor, MI, 48108, USA. **A Risk Forecasting Model of Cyanobacterial Toxin for Western Lake Erie.**

A continuous Bayesian Networks (cBN) model is proposed for forecasting the risk of high microcystin. The model is based on long-term monitoring data in the Western Basin of Lake Erie. Using spring TP loading from Maumee River as the predictor, the model builds upon the current NOAA HABs forecasting model to project temporal variability in microcystin concentrations, which can be used to estimate the likelihood of microcystin concentration exceeding thresholds for management purposes. The model can be updated using annual HABs monitoring data; as a result, the model can be refined over time. In addition to presenting the details of the model and the model validation results, the talk also discusses planned future improvements, including the capability of modeling spatial variability. *Keywords: Microcystis, Modeling, Risk assessment.*

QIU, H.[1], NIU, J.[2], and PHANIKUMAR, M.S.[1], [1]Department of Civil and Environmental Engineering, Michigan State University, East Lansing, MI, 48824, USA; [2]Earth and Environmental Science Area,Lawrence Berkeley National Laboratory, Berkeley, CA, 94720, USA. **Modeling Nitrogen Fate and Transport in Agricultural Basins in the Great Lakes Region.**

Nitrogen loading and transport in river basins are closely related to several environmental issues such as eutrophication. In this work, we describe an operator-splitting-based approach for multi-component reactive transport modeling of nitrogen fate and transport in agricultural basins in the Great Lakes region. This work provides a watershed-scale framework of nitrogen transport and reactions originating from multiple sources with interactions between the domains of soil, groundwater, overland and river networks. User-defined reaction modules make it possible to manipulate individual processes, evaluate the impacts of point sources, and to understand the evolving roles of nitrogen species in different domains. The modeling framework was tested on agricultural watersheds such as the Kalamazoo River watershed (5,200 km^2) in Michigan. Our results are expected to aid in the management of water resources, and in evaluating the impacts of agricultural activities.
Keywords: Hydrologic model, Nitrogen fate and transport.

QUINN, F.H.[2], CLITES, A.[1], and GRONEWOLD, A.D.[1], [1]NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Road, Ann Arbor, MI, 48108, USA; [2]NOAA-GLERL (Emeritus), 4840 S. State Road, Ann Arbor, MI, 48108, USA. **Reconciling Discontinuity of Temporal Flow Measurements for the Detroit River.**

The Detroit River is the lower part of the Huron to Erie corridor, a very important connecting channel in the Great Lakes system. Flow measurements have been made since the mid-1800's for purposes of monitoring hydraulic regime changes and computing monthly flows. Since 1958, monthly flows have been calculated for all of the connecting channels by U.S. and Canadian agencies under the auspices of the Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data, using a combination of unsteady flow models, stage-fall-discharge equations, and flow measurements. Recent analysis of flow measurements collected by the U.S. Army Corps of Engineers between 1962 and 2009 reveal internal discontinuities that may limit the use of the data. We suggest a strategy for using this historical flow data that acknowledges the inconsistencies, but allows use of all the data by deriving a more appropriate stage-fall-discharge equation for the Detroit River.
Keywords: Detroit River, Hydraulics, Modeling.

R

RAFFERTY, S.R.[1], BLAZER, V.S.[2], STAUFFER, J.R.[3], CERMAK, T.[1], and BRAHAM, R.[2], [1]Pennsylvania Sea Grant College Program, 301 Peninsula Drive, Suite 3, Erie, PA, 16505, USA; [2]United States Geological Survey, 11649 Leetown Road, Kearneysville, WV, 25430, USA; [3]The Pennsylvania State University, 432 Forest Resources Building, University Park, PA, 16802, USA. **Prevalence of intersex in Micropterus dolomieu collected from Presque Isle Bay and Long Point Bay.**

In 2013, the U.S. Department of State delisted the Presque Isle Bay Area of Concern partially in response to research showing that liver tumor rates in Presque Isle Bay, Pennsylvania and the reference site Long Point Inner Bay, Ontario were similar. Since the delisting, the question of whether or not other indicators (e.g. intersex) could be used to evaluate the ecological integrity of the Presque Isle Bay fish community has been raised. Intersex is a term used to indicate the presence of both male and female characteristics in an individual fish, including the presence of female oocytes within a male gonad or spermatocytes within a female gonad. While the cause(s) of intersex are not fully understood, many factors including exogenous steroids, temperature, behavior, and pollutants have been shown to influence sex differentiation in fish. Intersex, particularly testicular oocytes, in Micropterus dolomieu is being used more frequently as an indication of exposure to endocrine active compounds, including organochlorine pesticides, PCBs, heavy metals, pharmaceuticals, and surfactants. From 2013 to 2015, we assessed the prevalence of intersex in M. dolomieu collected from Presque Isle Bay and Long Point Bay. This presentation will highlight the results of these assessments. *Keywords: Fisheries, Ecosystem health, Endocrine disruption.*

RAKHIMBEKOVA, S.[1], O'CARROLL, D.M.[2], and ROBINSON, C.[1], [1]Western University SEB, 1151 Richmond Street, London, ON, N6A 3K7, CANADA; [2]University of New South Wales, Manly Vale, SW, 2093, AUSTRALIA. **Effect of varying wave conditions on the mobility of arsenic in a nearshore aquifer on the Great Lak.**

Groundwater-lake interactions play an important role in controlling the behavior of pollutants in nearshore aquifers and their ultimate flux to the lake. Dynamic groundwater flows and water exchange across the sediment-water interface (SWI) can set up strong geochemical gradients in a nearshore aquifer and affect the mobilization and transport of reactive pollutants (e.g. arsenic, phosphorus). The goal of this study was to assess the impact of intensified wave conditions on the behavior of arsenic in a nearshore aquifer to determine the hydrologic and geochemical factors controlling its mobility and transport to receiving nearshore waters of the Great Lakes. This study presents pore water and sediment data

illustrating the geochemical conditions in the nearshore aquifer during a period of varying wave conditions. Shifts in pH and redox gradients in response to the wave conditions caused shifts in the iron and arsenic distributions in the aquifer. Insight into the effect of transient wave conditions on arsenic mobility and transport in groundwater-lake environments is important for evaluating the potential risks associated with this toxic metalloid. The study findings also have significant implications for the fate of other reactive contaminants discharging through nearshore aquifers to lakes. *Keywords: Environmental contaminants, Water level fluctuations, Geochemistry.*

RALAHAMILL, L.[1], WELLS, M.G.[1], LI, J.Z.[1], and HOWELL, T.[2], [1]University of Toronto Scarborough, 1095 Military Trai, Toronto, ON, M1C1A4, CANADA; [2]Ontario Ministry of the Environment and Climate Change, 125 Resources Road, Toronto, ON, M9P 3V6, CANADA. **Evaluating the flushing mechanisms in the nearshore of South-eastern Georgian Bay.**

The flushing of water masses plays a dominant role in understanding the impact of land-based phosphorus upon the nearshore water quality of South-eastern Georgian Bay, Ontario. Georgian Bay is located east of the main body of Lake Huron and has a surface area of 15,000 km², and contains approximately 30,000 islands along the eastern coastline. Generally the water quality is very good, but there are concerns about the impact of ongoing development upon the many inlets and bays along the eastern shore. Detailed observations of nearshore water quality (e.g. conductivity, phosphorous, chlorophyll) from Shwanaga and Moon River Island regions show pronounced gradients, presumably driven by water circulation patterns. This region experiences seasonal thermal stratification and a significant barotropic variability in currents that is tied to variability in surface water levels. Here is a strong signal of tides at diurnal and semidurnal periods, but water movements appear to be driven by the diurnal tides at these locations. This suggests a well-mixed estuarine circulation. Numerical analysis will further be performed to obtain a better understanding of the flushing dynamics and the resulting phosphorus-productivity gradient across the South-eastern Georgian Bay. *Keywords: Georgian Bay, Water currents, Coastal processes.*

RAM, J.L., SHAH, M.P., GRUBER, A.J., and ALIAN, O.M., Wayne State University, 540 E. Canfield St, Dept. of Physiology, Wayne State University, Detroit, MI, 48201, USA. **New Technology to Ascertain Compliance with the IMO's Ballast Water Convention.**

Ratification of the International Maritime Organization's Ballast Water Convention (BWC) in 2016 will soon require ships, including those entering the Great Lakes, to manage ballast so that very few live organisms, including invasives and pathogens, will be discharged in ballast water. Verifying compliance involves quantification of live organisms in ballast to be discharged. Port controllers may want rapid indicative evidence of low organism levels before allowing discharge. The Ram Lab is developing an automated indicative system based on enzymatic activity that metabolizes fluorescein diacetate. We tested it at the Great Ships Initiative during a USGS test of a chlorine-based treatment system. We tested blinded samples (pretreatment, treated, or untreated), in two treatment tests, measuring activity for 10 - 50 um and > 50 um size organisms. The automated device differentiated pre-treatment (high activity) from post-treatment (low in treated; higher in control). Organism counts in control samples correlated with relative fluorescence. The test identified the complex GUI as a problem. Efforts to simplify the interface and sample transport system are in progress to make this compliance tool easier and more reliable to use. Supported by the Great Lakes Protection Fund, Project #964. *Keywords: Biological invasions, Ballast, Biomonitoring.*

RAM, J.L. and KASHIAN, D.R., Belle Isle Aquarium Science Laboratory and Field Facility, 900 Inselruhe Ave, Detroit, MI, 48207, USA. **Wayne State University field station: The Belle Isle Aquarium Science Laboratory and Field Facility.**

The Belle Isle Aquarium, designed by famed Detroit architect, Albert Kahn, opened in 1904 and is the oldest aquarium in the country still operating in its original building. After a temporary closure from 2005-2012, the Aquarium reopened with new staff, new fish, and new a will to develop new science and education programs (see http://detroitaquarium.weebly.com). A research laboratory was established in the basement in partnership with Wayne State University. Equipped with real-time PCR and other molecular equipment, new research microscopes, incubators for bacteria and algae, and a range of field equipment, the laboratory has been the site of research on interactions of algae on dreissenid mussel reproduction, molecular barcode studies on chironomids and water mites, eDNA technology for gar (the Aquarium owns all 7 known species), walleye mobility in Lake Erie, and ballast water compliance technology. The laboratory hosted a "24/7" intensive course in Molecular Aquatic Ecology that is planned to be given next in 2018. The laboratory encourages inquiries from other scientists who may want a "home base" for field work around Belle Isle, want a convenient place to do molecular work on organisms from the Detroit River or island wetlands, or want to work with Aquarium staff and the Aquarium collection of awesome fish. *Keywords: Education, Taxonomy, Biodiversity, Detroit River, Fish tagging.*

RAMAGE, H.R.[1], HOFFMAN, J.C.[2], PETERSON, G.S.[2], HATZENBUHLER, C.L.[2], BARGE, J.[2], PEARSON, M.S.[2], and LAUNSPACH, J.J.[3], [1]University of Minnesota Duluth, 1049 University Dr, Duluth, MN, 55812, USA; [2]US Environmental Protection Agency Mid-Continent Ecology Division, 6201 Congdon Blvd, Duluth, MN, 55804, USA; [3]SRA

International Inc., 6201 Congdon Blvd, Duluth, MN, 55804, USA. **Microhabitat Influence on Larval Fish Assemblages within Wetlands; Implications for Restoration.**

We examined larval and juvenile fish assemblage structure in relation to microhabitat variables within the St. Louis River Estuary, a drowned river mouth of Lake Superior. Fish were sampled in vegetated beds throughout the estuary, across a gradient of vegetation types and densities (including disturbed, preserved and post-restoration sites). Canonical correspondence analysis, relating species abundances to environmental variables revealed that plant species richness, turbidity and aquatic plant cover were most influential in structuring assemblages. Furthermore, plant species richness was positively correlated ($r=0.677$, $p<0.05$) with Tubenose Goby abundance, signifying evidence against the diversity-invasibility hypothesis. Results from this microhabitat analysis at this crucial life stage has potential to inform wetland restoration efforts within the St. Louis River Estuary and other Great Lake Coastal Wetlands. *Keywords: Biological invasions, Restoration, Habitats, Wetlands.*

RASIAH, S. and WELLEN, C.C., University of Windsor-GLIER, 2990 Riverside Drive West, Windsor, ON, N9C 1A2, CANADA. **Cold Region Hydrology: A Modelled Assessment of Winter Nutrient Runoff Processes.**

Winter nutrient losses within the Great Lakes watersheds region have a significant impact on the overall quality of neighbouring surface waters. During the fall, semi-saturated soil begins to freeze, followed by snow cover accumulation throughout the winter and a snowmelt during the early spring which plays a major role in overland flows. Given the substantial amount of field data that have already been collected, a simulation-based approach using existing datasets will be taken which will allow the feasibility of field scales to be tested, particularly cold tile drainage areas. Because the majority of tile drainage flow patterns datasets are derived from warm regions of the USA, we are presented with an uncommon opportunity to test our models on cold tile drainage flow patterns to determine the range of watershed conditions that affect field-scale nutrient runoff. Using the University of Saskatchewan's Cold Region Hydrological Model the intent of this study is to establish an understanding of snow accumulation patterns within the Great Lakes region[1]. The development of a more precise understanding of specific snow and water flow patterns can help farmers improve their contingency plans, potentially leading to an increase in efficient fertilizer application and a reduction in surface water pollution. *Keywords: Hydrologic cycle, Winter nutrient runoff, Great Lakes basin, Agriculture, Environmental policy, Ontario Ministry of Natural Resources.*

RAYMOND, H.A., BRILAND, R.A., and KLEI, A.J., Ohio EPA, 50 W. Town Street, Columbus, OH, 43215, USA. **Use of a Multi-plex qPCR Assay for HAB Monitoring in Ohio.**

In 2016, Ohio EPA began utilizing a multi-plex qPCR assay that identifies and quantifies total cyanobacteria (16s), microcystins production (mcyE), saxitoxins production (sxtA), and cylindrospermopsin production (cyrA). Source water samples were collected at 118 public water systems (PWSs) bi-weekly and analyzed for microcystins and qPCR. Saxitoxins and cylindrospermopsin were analyzed if sxtA or cyrA were detected. At 22 inland lakes, at least three samples were collected and analyzed for qPCR, microcystins, saxitoxins, cylindrospermopsin, and phytoplankton enumeration. Microcystins were detected in the source water for 39 PWSs and 12 inland lakes. 2% of PWS samples and 15% of inland lake samples had microcystins detections without corresponding mcyE detections. At several sites, detection of mcyE preceded microcystins detections by 1-4 weeks. sxtA was detected at 33 PWSs and 14 inland lakes, and saxitoxins were detected at 15 PWSs and 10 inland lakes. Less than 1% of PWS samples and 1.9% of inland lakes samples had saxitoxins detections without corresponding stxA detections. Cyanotoxin concentrations were low in samples without gene detections. At one PWS, mcyE, sxtA, and cyrA were all detected, demonstrating the multi-plex functionality. qPCR out-performed cell counts as a predictor for inland lake cyanotoxin production *Keywords: Monitoring, QPCR, Harmful algal blooms, Cyanotoxins, Lake Erie.*

READ, J.G.[1] and DROUIN, R.[2], [1]University of Michigan Water Center, 625 E Liberty, Suite 300, Ann Arbor, MI, 48104, USA; [2]Ontario Ministry of Natural Resources and Forestry., London, ON, CANADA. **Governance and Coordination in a Bi-national AOC: the St Clair and Detroit River AOCs as case study.**

Two significant beneficial use impairments (BUIs) in the St Clair and Detroit River binational areas of concern have been degraded fish and wildlife populations and loss of fish and wildlife habitat. In the late 1990s, federal, state/provincial and academic fishery biologists hypothesized that these impairments were due to historic loss of spawning habitat for fishes that prefer spawning in fast-flowing water on rocky substrate with lots of interstitial space. Over the ensuing 20 years an unprecedented binational, multi-disciplinary and multi-sector team formed, determined to address these two impairments. This presentation will address the barriers and opportunities the group has encountered on its journey to building an enduring bi-national partnership that, in turn, will soon see the two BUIs delisted. *Keywords: St. Clair River, Governance, Detroit River, Bi-national, Habitats.*

READ, L.K., YATES, D.N., GOCHIS, D., and SAMPSON, K., National Center for Atmospheric Research, Boulder, CO, USA. **Current and Future Efforts in Development of Lake Accounting for the National Water Model.**

The National Water Model (NWM) is a continental-scale, fully operational, hydrologic model maintained by the National Weather Service the National Oceanic and Atmospheric Administration's Office of Water Prediction. The NWM model simulates streamflow and other terrestrial hydrologic variables in real-time and in three forecast cycles over the continental U.S. along 2.7 million reaches in the National Hydrography Dataset. Sophistication of the representation of lake physics and management accounting is a priority for upcoming versions. This presentation discusses the ongoing efforts to improve lake accounting of surface fluxes (e.g. evaporation) in the NWM, focusing on (1) the inclusion of the Great Lakes (GL) into the NWM domain, and (2) the integration of a one-dimensional lake model to compute lake fluxes currently being tested for implementation. Related to the GL, challenges and opportunities associated with including and simulating the region will be discussed, as well as ongoing activities with the NOAA GL Environmental Research Laboratory to improve simulation efforts. The presentation demonstrates results from the 1-D lake model, and discusses the process for incorporating it into the operational schemes of the channel routing and inflow/outflow components of the NWM through a case study in Lake St. Clair. *Keywords: Lake St. Clair, Hydrologic modeling, Water level.*

READ, R.A. and CITRIGLIA, M., North East Ohio Regional Sewer District, 4747 E. 49th St, Cuyahoga Heights, OH, 44145, USA. **Microcystin ELISA: Comparison of the Manual Method vs. the Automated CAAS method.**

The Abraxis Cyanotoxin Automated Assay System (CAAS) is currently being used for the analysis of water samples for total microcystin/nodularin by ELISA. Use of this system provides the advantages of automation, including increased efficiency in workflow and in analyst time, and less variation in calibration/standards, providing more accurate and reliable results. Validation of the instrument for use at NEORSD included initial demonstration of capability, analysis of precision and accuracy from drinking water, and LCMRL confirmation. Additionally, results from the CAAS were compared with those from the manual method to demonstrate matching or improved performance. To increase recovery, specific parameters of the original CAAS script were changed, and results compared to both the manual method and the original script. Initial demonstration of capability results showed recoveries of 98.6%, 92.3%, and 111% of MC-LR for the manual, CAAS, and CAAS modified method, respectively. Percent recoveries were also comparable in matrix samples at 109%, 94%, and 101%. However, the manual method demonstrated higher variability for quality control and standard samples compared with the CAAS system,

with the automated method providing a greater success rate for the assay. *Keywords: Harmful algal blooms, ELISA, Microcystis.*

REAVIE, E.D.[1], ALEXSON, E.E.[1], ESTEPP, L.R.[1], SGRO, G.V.[2], BRAMBURGER, A.J.[1], CAI, M.[1], PILLSBURY, R.W.[3], and SHAW CHRAÏBI, V.L.[4], [1]Natural Resources Research Institute, University of Minnesota Duluth, 5013 Miller Trunk Hwy, Duluth, MN, 55811, USA; [2]Department of Biology, John Carroll University, Cleveland Heights, OH, USA; [3]University of Wisconsin Oshkosh, Oshkosh, WI, USA; [4]Tarleton State University, Stephenville, TX, USA. **Paleolimnology Provides Early Warnings of Impacts from Eutrophication, Invasive Species and Climate.**

Multiple stressors need management options in the Laurentian Great Lakes and paleolimnology provides tools to track changing conditions and predict future impairments. We can provide early data reflecting aquatic impacts before they are realized in higher trophic levels, thereby predicting future conditions. Here are two examples of how paleolimnology is being used to inform management decisions for the Great Lakes. (1) The RAP for the St. Louis River requires removal of beneficial use impairments associated with nutrients. Sediment cores were analyzed for physical, chemical and biological remains and long-term changes in fossil algae provided evidence that some areas have improved since nutrient abatement. However, nearshore areas show increasing nutrients and algal abundance, likely due to stressors that are not fully understood (climate change, sediment nutrients). Recommendations for delisting and future studies are forthcoming. (2) A diatom-based paleolimnological study has revealed the first biological effects of climate change on the base of the food webs in all five Great Lakes: an increasing relative abundance of *Cyclotella sensu lato*. Atmospheric warming is the strongest correlate with these changes, and recommendations are made regarding the eventual impacts on food webs throughout the Great Lakes system. *Keywords: Paleolimnology, Nutrients, Diatoms, Areas of Concern, Climate change.*

REDDICK, D.T.[1], DOKA, S.E.[1], JACOBS, C.[2], WYNIA, A.[1], JOHNSON, K.[2], and WHITE, A.[3], [1]Fisheries & Oceans Canada, 867 Lakeshore Rd., Burlington, ON, L7S 1A1, CANADA; [2]Walpole Island First Nation Heritage Centre, PO Box 22032, Wallaceburg, ON, N8A 5G4, CANADA; [3]Environment & Climate Change Canada, 4905 Dufferin Street, Downsview, ON, M3H 5T4, CANADA. **St. Clair River Delta Fish Habitat Assessment 2015.**

Fisheries and Oceans partnered with Walpole Island First Nation to conduct a fish habitat assessment within the delta, to help inform the St. Clair River Remedial Action Plan on the condition of the available fish habitat. The primary objective was to assess aquatic habitat characteristics (vegetation, species composition and percent cover) as well as the

abundance and diversity of the fish community using the habitat. This includes temperature and oxygen profiles at a subset of sites, sediment size analysis and depth profiles. WIFN community members helped identify areas of community interest and ensured a diversity of habitat types were identified. They were also essential members to the project sampling crews *Keywords: Habitats, First Nations, Fish.*

REDDY, N.[1], MONSHI, M.[1], ALAME, K.[1], MCELMURRY, S.P.[2], KASHIAN, D.R.[3], and PITTS, D.K.[1], [1]Dept Pharmaceutical Sciences, Wayne State University, 259 Mack Avenue, Detroit, MI, 48202, USA; [2]Civil and Environmental Engineering, Wayne State University, 2100 Engineering Building, Detroit, MI, 48202, USA; [3]Biological Sciences, 2125 Biological Sciences Building, Detroit, MI, 48202, USA. **Sub-lethal behavioral effects of chlorpyrifos and 4-nonylphenol on Daphnia pulex.**

Insecticides are commonly found in surface water as contaminants of emerging concern. Some of the acetylcholinesterase inhibitors (AChE-Is) have been reported to be endocrine disrupting chemicals (EDCs). Detergent metabolites, such as 4-nonylphenol (4-NP), also inhibit AChE (Li, 2008). Using an optical tracking technique, Zein et al. (2014) previously demonstrated that sub-lethal behavioral effects of AChE-Is could be detected in the non-target aquatic crustacean, Daphnia pulex, and that diazinon (AChE-I) interacted with 4-NP to produce an additive or synergistic effect on behavior (Zein et al., 2015). In the present study the sub-lethal effects of the AChE-I, chlorpyrifos (CPS), and 4-NP were further explored using optical tracking. CPS (0.31nM to 5nM) elicited a biphasic behavioral response, eliciting behavioral stimulation at lower concentrations and immobility at higher concentrations. Similarly, 4-NP elicited behavioral stimulation at lower concentrations (0.25 μM) and immobility at higher concentrations (4 μM). Since 4-NP has been previously reported to augment the effects of diazinon on swimming behavior, the hypothesis that alkylphenols, such as 4-NP, have the potential to interact with AChE-Is and produce additive or synergistic toxic effects will be further tested by combined 4-NP and CPS exposure. *Keywords: Environmental contaminants, Crustaceans, Toxic substances.*

REED, E.M.[1], THOMAS, S.M.[2], CHICK, J.H.[3], and CZESNY, S.J.[1], [1]Lake Michigan Biological Station, Illinois Natural History Survey, University of Illinois U-C, 1816 S. Oak st., Champaign, IL, 61820, USA; [2]Waterford Fisheries Station, Michigan Department of Natural Resources, 7806 Gale Road, Waterford, MI, 48327, USA; [3]Great Rivers Field Station, Illinois Natural History Survey, University of Illinois U-C, Alton, IL, 62002, USA. **Nearshore Zooplankton Communities in Lake Michigan and Implications for Asian Carp Establishment.**

Nearshore regions in the Great Lakes provide an important transition zone from the watershed to offshore waters and serve as spawning and nursery habitat for many fish. Zooplankton communities are an integral component of these nearshore systems, both as nutrient cyclers and a food source for higher trophic levels. However, recent anthropogenic alterations and invasive species introductions have dramatically changed species assemblages in the Great Lakes, including zooplankton communities. To better understand zooplankton's role within critical nearshore areas and how they may affect invasive species establishment, we compared zooplankton community assemblages around Lake Michigan, including in harbors, drowned river mouth lakes, open-water locations, and Green Bay over two years. This nearshore zooplankton community assessment can help determine energy available to consumers within Lake Michigan's food web and provide insights to emerging community structures in this dynamic system. In particular, our findings highlight how nearshore zooplankton communities have the potential to facilitate or hinder Asian carp establishment in the Great Lakes. *Keywords: Zooplankton, Asian Carp, Lake Michigan, Nearshore.*

REEVES, H.W.[1] and HUNT, R.J.[2], [1]USGS Michigan-Ohio Water Science Center, 6520 Mercantile Way, Suite 5, Lansing, MI, 48911, USA; [2]USGS Wisconsin Water Science Center, 8505 Research Way, Middleton, WI, 53562, USA. **Incorporating groundwater dynamics into water management decisions in the Great Lakes.**

Water-management decisions in the Great Lakes basin often need to account for the dynamics of the groundwater system in response to management actions and climatic variability. Groundwater is a major resource in the Great Lakes basin that provides municipal, domestic, industrial and irrigation supply. Understanding groundwater dynamics is important for management of water supplies from surface water and maintaining flows to support critical aquatic habitats, recreation, and transportation. Groundwater wells often serve as water supply in times of drought. Use of groundwater, however, does not shield surface-water supplies from impacts because pumping wells can capture the groundwater contribution to streamflow or induce flow from streams into aquifers. Hydroclimatic drivers may couple with management decisions in a non-linear ways, and feedback may be important. Groundwater systems have boundaries, thus groundwater may need to be managed at scales smaller than a Great Lake watershed. Current management tools, however, are often not tuned for an individual groundwater system and usually cannot account for non-linearity and feedback. Hydrologic data availability and the hierarchy of tools to support groundwater-management decisions at various spatial and temporal scales will be explored. *Keywords: Hydrologic budget, Modeling, Decision making.*

REISINGER, A.J.[1], AXLER, R.P.[2], COOPER, M.J.[3], JOHNSON, L.B.[2], RUETZ III, C.R.[4], STEINMAN, A.D.[4], and UZARSKI, D.G.[1], [1]Central Michigan University, Mount Pleasant, MI, 48859, USA; [2]Natural Resources Research Institute, University of Minnesota Duluth, Duluth, MN, 55812, USA; [3]Burke Center for Freshwater Innovation, Northland College, Ashland, WI, 54806, USA; [4]Annis Water Resources Institute, Grand Valley State University, Muskegon, MI, 49441, USA. **Natural and anthropogenic disturbances affect water quality of Great Lakes coastal wetlands.**

Coastal wetlands of the Laurentian Great Lakes are subject to a range of natural and anthropogenic disturbance. The structure and function of coastal wetlands is controlled by chemical and biological responses to these disturbances, yet the relative importance of different disturbances for controlling various components of coastal wetlands is unclear. From 2011 - 2015, we monitored >1000 wetland zone-year combinations to quantify the effect of disturbance on water quality (e.g., nutrients). We developed an anthropogenic disturbance gradient that accounted for human land-use, and we also quantified the effective fetch for each wetland as a measure of natural disturbance. Ultimately, we estimated how different components of water quality responded to natural and/or anthropogenic disturbances. Preliminary results suggest a threshold for anthropogenic disturbance below which water quality is not drastically affected by land-use change, but above which water quality decreases dramatically. In contrast, natural disturbances controlled water quality under specific wetland vegetation, but this was not consistent across wetland-type. These results suggest that minor reductions in anthropogenic disturbance can have marked effects on improving water quality, but that natural disturbances must be considered when managing coastal wetlands. *Keywords: Water quality, Coastal wetlands, Nutrients.*

REISINGER, L.S., PANGLE, K.L., COOPER, M.J., LEARMAN, D.R., UZARSKI, D.G., WOOLNOUGH, D.A., BUGAJ, M.R., BURCK, E.K., DOLLARD, R.E., GOETZ, A., GOSS, M., GU, S., KARL, K., ROSE, V.A., SCHEUNEMANN, A.E., WEBSTER, R., WELDON, C.R., and YAN, J., Central Michigan Unviersity, Mount Pleasant, MI, 48859, USA. **The influence of water currents on community and ecosystem dynamics in coastal Lake Michigan.**

Despite their ecological and economic importance, coastal communities and ecosystem processes in large lakes have been understudied compared to those offshore. We investigated temporal variability and the influence of water currents on the abundance and community composition of coastal organisms in northern Lake Michigan. We sampled nutrients, phytoplankton, zooplankton, periphyton, benthic invertebrates, and fish on the coast of Beaver Island, MI with high temporal frequency over two summers and obtained accompanying water current data. We also periodically sampled offshore to examine

connectivity between coastal and offshore habitats. Our results suggest that phytoplankton abundance was driven by nutrient fluxes from offshore, and zooplankton abundance and composition was driven by the flux of zooplankton from offshore into the coastal zone. Seasonal peaks in plankton abundance differed between years, possibly due to differences in the timing of stratification which can affect dreissenid mussel grazing. Abundance and composition of benthic organisms and fish were less variable over short timescales. Understanding variability in coastal communities may enhance interpretation of monitoring data and assist scientists in designing effective protocols for investigating large lake ecology. *Keywords: Species composition, Coastal ecosystems, Water currents.*

RICE, K.N.[1] and EVANS, K.M.[2], [1]GEI Consultants, Inc., 5225 Edgewater Drive, Allendale, MI, 49401, USA; [2]West Michigan Shoreline Regional Development Commission, 316 Morris Avenue, Suite 340, Muskegon, MI, 49443, USA. **Habitat Restoration of Two Former Celery Fields, Bear Creek, Muskegon Lake Area of Concern.**

Bear Lake and its main tributary, Bear Creek, are part of the Muskegon Lake Area of Concern (AOC). Muskegon Lake was designated an AOC in 1985 due to ecological problems caused by industrial discharges, shoreline alterations, and the filling of open water and coastal wetlands. After completion of the Bear Creek and other restoration projects, the U.S. EPA expects to delist the Muskegon Lake AOC as early as 2018. The subject 36-acre Bear Creek site is a location where earthen berms were historically installed between two celery farm ponds and the creek, and have prevented surface water and fish passage between these aquatic ecosystems since the 1930's. In 2002, farming practices were discontinued and the fields were re-flooded, but the dikes remained intact. In order to hydrologically reconnect the abandoned celery pond muck fields and restore fish and wildlife habitat, many factors and challenges had to be taken into account. Abandoned oil wells, high levels of phosphorus in the muck soils and surface water, multiple and sometimes conflicting stakeholder goals, hydrologic implications of berm removal, perimeter road structural integrity, and long-term maintenance were all evaluated and integrated into restoration final design. This presentation will discuss the techniques used to design and implement the restoration project. *Keywords: Habitats, Phosphorus, Great Lakes Restoration Initiative (GLRI), Muskegon Lake AOC, Wetlands, Hydrologic reconnection.*

RICH, M.[1] and KRANTZBERG, G.[2], [1]Environment Network, 10138 Highway, Collingwood, ON, L9Y3K1, CANADA; [2]McMaster University, Boothe School of Engineering Practice and Technology, 1280 Main St. W, Hamilton, ON, L8S 4L8, CANADA. **Sustaining Stewardship and Community Engagement after Delisting the Collingwood Harbor AOC.**

In 1994 Collingwood Harbour was the first Canadian Area of Concern (AOC) to be delisted. The area was designated an AOC in 1987 because of beneficial use impairments resulting from nuisance algae, contaminated sediment, fish advisories and habitat loss. Major remedial actions included reducing phosphorous from the local sewage treatment plant, removing contaminated sediment, protecting local wetlands, and rehabilitating fish and wildlife habitat. The Environment Network was formed in 1993 as a nonprofit organization to provide a central location for work under the Collingwood Harbour Remedial Action Plan (RAP). Prior to the AOC's delisting, the Environment Network became part of the Ministry of Environment and Energy's Green Communities Initiative to continue the work of the RAP. The Greening of Collingwood, a strategic plan promoting pollution prevention practices for residents, businesses and industries, was created to engage the entire community in environmental initiatives. It now provides a place for people to learn how to operate their business or home in an ecologically and an economically sustainable manner. This presentation showcases how environmental stewardship and community engagement was sustained following the delisting of the AOC, and how Collingwood continues to benefit today. *Keywords: Cleanup, Area of Concern, Public education, Delisting, Impared water use, Sustainability.*

RICHARDS, E.A.[1], OUELLET, F.[1], BENOY, G.[2], RATTAN, K.J.[1], WONG, I.[1], GUDIMOV, A.[3], KIM, D.K.[3], and ARHONDITSIS, G.B.[3], [1]Environment and Climate Change Canada, 867 Lakeshore Road, P.O. Box 5050, Burlington, ON, L7S 1A1, CANADA; [2]International Joint Commission, 234 Laurier Avenue West, 22nd Floor, Ottawa, ON, K1P 6K6, CANADA; [3]University of Toronto, 1265 Military Trail, Toronto, ON, M1C 1A4, CANADA. **The effects of wet and dry conditions on nutrient loads in the Red Assiniboine Basin.**

Climate change can affect the timing and quantity of runoff and streamflow in primarily agricultural watersheds such as the Red Assiniboine Basin (RAB) (67% crop and pasture) which straddles the Canada-United States border and includes two provinces and three states. The impacts of runoff and streamflow are expected to be more pronounced in agricultural watersheds because of engineered drainage and loss of wetlands. Recent field studies (2013 to 2014) in the RAB, which is prone to flooding, show significant differences in nutrient loads and fraction dynamics between wet and dry years. Regional-scale water quality models that are typically used to simulate nutrients often rely on input parameters that span across multiple years which represent average conditions. RAB, was used as a case study to develop tools to identify and characterize wet dry years. Geostatistical analyses were performed using meteorological and hydrological data that spanned multiple years (2003 to 2015). Field observations from 2013 and 2014 were used to verify statistical analyses. The implications of using wet and dry years to model watershed processes will be discussed. *Keywords: Bayesian loading estimates, Red Assinibione Basin, Eutrophication.*

RICHMAN, L.A.[1] and SANTIAGO, R.[2], [1]Ontario Ministry of Environment and Climate Change, Toronto, USA; [2]Environment and Climate Change Canada, Toronto, CANADA. **CONTAMINATED SEDIMENT MANAGEMENT IN CANADIAN AOCs: Bringing us Closer to Restoration and Delisting.**

There are 17 Areas of Concern (AOC) on the Canadian side of the Great Lakes. Contaminated sediment is an important issue at most of these AOCs and a major impediment to the restoration of Beneficial Use Impairments. The assessment and management of contaminated sediment in the Great Lakes required a consistent, transparent and scientifically valid approach. Accordingly, step by step guidance using a rule based, ecosystem approach to assessing the risk of contaminated sediment was developed by Canada/Ontario government scientists to provide direction for sediment management decisions. This paper will evaluate the development and implementation of sediment management strategies in AOCs including the development of risk based remedial action goals and objectives; stakeholder engagement and consultation, remedy selection and performance, long term monitoring and lessons learned. *Keywords: Sediments, Environmental contaminants, Remediation.*

RICHTER, C.A.[1], EVANS, A.N.[2], ZAJICEK, J.L.[1], CORNMAN, R.S.[3], HEPPELL, S.A.[2], and TILLITT, D.E.[1], [1]U.S. Geological Survey, Columbia Environmental Research Center, 4200 New Haven Rd., Columbia, MO, 65201, USA; [2]Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR, USA; [3]U.S. Geological Survey, Fort Collins Science Center, Fort Collins, CO, USA. **De novo production of thiaminase by alewife, a preferred prey fish for lake trout in the Great Lakes.**

In the Great Lakes, thiamine deficiency is an impediment to restoration of native lake trout. The non-native prey fish, alewife contains elevated levels of type I thiaminase, an enzyme that degrades thiamine, leading to thiamine deficiency in predatory salmonine fish. The source of thiaminase in alewife has been controversial. We present evidence that alewife have a gene encoding thiaminase and produce thiaminase protein de novo. We first identified a gene in zebrafish with homology to a partial protein sequence of thiaminase previously identified in red cornetfish. When the zebrafish putative thiaminase homolog was expressed in bacteria, the isolated recombinant protein had thiaminase activity. A homolog to the zebrafish thiaminase gene was identified in alewife. The size and isoelectric point predicted for the protein encoded by the alewife putative thiaminase gene match the size and isoelectric point of thiaminase isolated from alewife tissue. Surprisingly, the fish thiaminase

protein sequences show a weak but significant alignment to bacterial TenA, a type II thiaminase that acts in a thiamine salvage pathway. The physiological function of thiaminase in fish is unknown. However, finding that alewives produce thiaminase allows management strategies to protect salmonine populations by focusing on prey species of concern.
Keywords: Alewife, Thiaminase, Lake trout.

RIDAL, J.J.[1] and TWISS, M.R.[2], [1]St. Lawrence River Institute for Environmental Science, Clarkson University, Cornwall, ON, K6H 4Z1, USA; [2]Clarkson University, Potsdam, NY, 13699, USA. **The tri-national St. Lawrence River AOC (Canada, Akwesasne, USA): Paramount importance of community.**

The effectively tri-national AOC that encompasses the communities of Cornwall (ON), Akwesasne (Mohawk Nation) and Massena (NY) in the region of the Moses-Saunders hydropower dam (est. 1958) and locks of the St. Lawrence Seaway (est. 1959). It is a geographically large (40 km Canada, 20 km US) and complex (four rivers; dam, canals) and politically complicated (three nations, two US counties, one Canadian county, bordering on the Province of Quebec). Abundant electricity from the dam supported heavy industry in the communities of Massena and Cornwall, with adverse direct impacts on both communities and Akwesasne. Hydrodynamics retained pollution of mercury (Canada) and PCBs and PAHs (US) on their respective nearshore environments, together with initially different response mechanisms, resulted in two separate remedial actions plans (RAPs). The approach and current progress for each RAP will be outlined, together with the limitations of the prescribed technological approach to AOC de-listing in relation to this complex tri-national AOC. *Keywords: St. Lawrence River, Environmental contaminants, Coastal ecosystems.*

RIDENOUR, C.H., PARSONS, C.T., and VAN CAPPELLEN, P., Ecohydrology Research Group, University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L 3G1, CANADA. **Nutrient Silicon Cycling in Hamilton Harbour Area of Concern (Ontario, Canada).**

The relative availability of the macronutrients phosphorus (P), nitrogen (N), and silicon (Si) influences phytoplankton community composition and water quality in eutrophic environments. Although many freshwater bodies, including Hamilton Harbour, are assumed to be P limited, anthropogenic enrichment with P and N is typically greater than enrichment with Si. This differential loading of nutrients from anthropogenic sources can drive stoichiometric limitation of Si with respect to P (Si:P < 16:1) which favours the growth of non-siliceous algae, including that of harmful species. A mass balance model of reactive Si and total dissolved P in the Hamilton Harbour Great Lakes Area of Concern has been developed to determine if the system is a net source or sink of Si, and if Si is limiting the

growth of diatom algae. The model incorporates dissolved and reactive particulate Si, and considers inputs and outputs to the water column over monthly and annual timescales. Results indicate that Hamilton Harbour is a net Si sink and that Si was more limiting than P throughout 2016, potentially contributing to the occurrence of harmful algal blooms. Our findings advance the understanding of the biogeochemical interactions occurring within Hamilton Harbour, and could help guide future nutrient management strategies. *Keywords: Biogeochemistry, Silicon, Harmful algal blooms, Hamilton Harbour.*

RIFENBURGH, A.M.[1], KANE, D.D.[1], and SINGER, S.[2], [1]Defiance College, Defiance, OH, 43512, USA; [2]Defiance County Soil and Water Conservation District,, Defiance, OH, 34512, USA. **Water Quality of the Upper Maumee River: A Two Year Assessment.**

The Maumee River, the largest tributary to the Great Lakes, is a major contributor of non-point source pollution to Lake Erie. Land use in its watershed is greater than 70 percent agricultural and thus nutrient runoff is a large concern and has been shown to contribute to harmful algal blooms in Lake Erie. In 2013 from spring to fall, four sites were sampled on the Upper Maumee River, which stretches from Fort Wayne, IN to Defiance, OH. The sites were selected to be in a diverse range of land use types, with one each in an urban, suburban, rural town, and agricultural area. Once a month at each site, Secchi depth was measured and a YSI multiprobe was used to measure temperature, dissolved oxygen, and pH. Water samples were also taken, and the concentrations of nitrate, phosphate, and ammonia were measured using Hach colorimetry nutrient tests. Chlorophyll a and blue green algae cell count were estimated using a handheld fluorometer. We found that mean nitrate and phosphate concentrations were well above the target levels set by the Upper Maumee Watershed Partnership. Future monitoring would provide a better understanding of the nutrient dynamics of the river and help evaluate the efficacy of current programs to reduce non-point source pollution in the watershed. *Keywords: Harmful algal blooms, Maumee River, Phosphorus, Nutrients.*

RIGGIO, M.A. and ALLEN, B.A., Hyde Marine, 2000 McClaren Woods Drive, Corapolois, PA, 15108, USA. **Examining Flow Dynamics in Ballast Water Management Systems.**

With the recent ratification of the 2004 International Convention for the Control of Ships' Ballast Water and Sediments, the need to install ballast water management systems onboard existing vessels is expected to grow to an $18 - $25B USD market in the coming few years. As ballast water management systems are added to vessels, these systems will invariably affect the ballasting of ships systems and without a careful study of the dynamics of introducing both a fine mesh mechanical filter and a disinfection stage, the performance of a BWMS onboard a vessel may be compromised significantly. This paper will examine the hydrodynamic impacts of installing a ballast water management system both in the engine room and on deck, the flow dynamics required for proper operation of fine mesh, self-cleaning ballast water treatment filters, and the relative impacts to ballast flow and how these impacts may affect proper sizing of the ballast water management system. The paper will be based both on theoretical design and calculation as well as real-world experience stemming from nearly 400 installed UV-based ballast water treatment systems. The paper should have value for both ship owners, designers, installers, and ballast water treatment system manufacturers who may have experienced variable system performance. *Keywords: Ballast, Invasive species, Transportation.*

RILEY, S.R.[1], EVANS, A.N.[2], RINCHARD, J.[2], ZAJICEK, J.L.[4], RICHTER, C.A.[4], KRUEGER, C.C.[5], TILLITT, D.E.[4], and HEPPELL, S.A.[2], [1]U.S. Geological Survey, Great Lakes Science Center, Ann Arbor, MI, 48105, USA; [2]Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR, 97331, USA; [3]Department of Environmental Science and Biology, The College at Brockport - SUNY, Brockport, NY, 144420, USA; [4]U.S. Geological Survey, Columbia Environmental Research Center, Columbia, MO, 65201, USA; [5]Center for Systems Integration and Sustainability, Michigan State University, East Lansing, MI, 48823, USA. **Comparison of two trophic biomarkers to describe the diets of Great Lakes planktivorous fishes.**

Understanding trophic connections among fish species is essential for evaluating many questions of ecological interest. Traditional microscopic examination of fish diets allows excellent taxonomic resolution but is labor intensive and provides only a single spatial and temporal snapshot of the diet. Trophic biomarkers such as fatty acid signatures have the potential to provide a more integrated measure of diet but lack the species-specific information that can be garnered from macroscopic examination. We examined the diet and fatty acid signatures of 8 species of largely planktivorous fish collected across diverse locations in the Great Lakes and assessed whether the two different methods produced similar or different representations of trophic structure when analyzed using Non-metric Multidimensional Scaling. We will discuss the degree to which these two trophic biomarkers resulted in similar understandings of trophic relationships among planktivores.
Keywords: Fish, Fatty acids, Diets, Food chains.

RINCHARD, J.[1], FUTIA, M.[1], LANTRY, B.F.[2], LANTRY, J.[3], GORSKY, D.[4], and JOHNSON, T.[5], [1]The College at Brockport - State University of New York, Brockport, USA; [2]U.S. Geological Survey - Lake Ontario Biological Station, Oswego, USA; [3]New York State Department of Environmental Conservation - Lake Ontario Unit, Cape Vincent, USA; [4]U.S. Fish and Wildlife Service - Lower Great Lakes Fish and Wildlife Conservation Office, Basom, USA; [5]Ontario Ministry of Natural Resources and Forestry - Aquatic Research and Monitoring Section, Picton, CANADA. **Thiamine Concentrations and Fatty Acid Signatures of Lake Ontario Lake Trout - 2013 Monitoring.**

Restoration of naturally reproducing Lake Trout populations is the major focus of an international effort in Lake Ontario. Although sporadic natural reproduction is occurring, abundance of natural recruits is below target numbers. Alewives are one of the key impediments limiting Lake Trout natural reproduction through direct predation of eggs and fry, and effects on embryo survival linked to inadequate egg thiamine concentrations. The objectives of this study were to determine the concentration of thiamine in Lake Trout eggs and muscle, and to evaluate Lake Trout diet using fatty acid signatures. Lake Trout were sampled throughout Lake Ontario in 2013. Thiamine concentrations were measured in eggs and muscle using high performance liquid chromatography, whereas fatty acid signatures were determined in belly flap using gas chromatography/mass spectrometry. Total thiamine concentration in eggs averaged 11.5 ± 7.5 nmol/g (n=86). Males and females presented similar levels of total thiamine in their muscle (4.0 and 4.7 nmol/g, respectively). Fatty acid signature analysis revealed that Lake Trout diet is composed of Alewife and Round Goby. This study indicates that thiamine concentrations in Lake Ontario Lake Trout were above the recommended threshold for successful reproduction of 4 nmol/g during 2013.
Keywords: Vitamin B, Fatty acids, Lake trout.

<u>RIOS MENDOZA, L.M.</u>, JOHNSON, C., and NYECK NYECK, M., University of Wisconsin Superior, Belknap and Catlin, Superior, WI, 54880, USA. **Small plastic particles with huge environment impacts in our freshwater systems.**

Microplastics are becoming one of the most cited emergent contaminants in the last decade. These tiny synthetic polymers are associated with human activity. The inadequate disposal of plastics has made this material a ubiquitous pollutant on beaches, rivers, lakes, and oceans around of the world. Microplastic particles are a new type of pollution reported in the Great Lakes with unknown impacts in the ecosystem and human health. Little information is currently available on the composition, distribution, or fate of microplastic debris in the western end of Lake Superior and St. Louis River Estuary. The aims of this research are to identify possible sources, abundance, and the potential of microplastics to be ingested by fish. In this study we collected a total of 35 samples during summer, 2016. There were 17 samples from surface waters using a manta trawl, 4 samples from effluent water from four wastewater treatment plants, and 7 beaches (samples from 100 m and 1 m2). To determine the type of synthetic polymer we are using a FTIR Micro Spectrophotometer. The microplastics were classified by color, size, pellets, fibers, and fragments. The first results from the analysis of 12 manta samples showed in average 18 fibers, 25 fragments, and 4

microbeads (from cosmetic products) per sample. *Keywords: Lake Superior, Environmental contaminants, Microplastics, St Louis River Estuary.*

RISENG, C.M.[1], WEHRLY, K.E.[2], WANG, L.[3], and MASON, L.[2], [1]University of Michigan, 440 Church St, Ann Arbor, MI, 48109, USA; [2]MDNR Institute of Fisheries Research, 400 N. Ingalls, Ann Arbor, MI, 48103, USA; [3]International Joint Commission, 100 Ouellette Ave, Windsor, ON, N0A 6T3, CANADA. **An ecological Classification for the Great Lakes: Using Ecological Variables to Map Aquatic Habitat.**

Due to its ecosystem complexity and spatial extent of the Laurentian Great Lakes, a spatial classification is needed to map, protect, and manage resources and to provide a framework for understanding the similarities and differences among ecological types of spatial units of the Great Lakes. We developed a spatially explicit spatial classification and mapping of unique ecological units using ecological and environmental variables for the Great Lakes aquatic ecosystem. Each delineated unit has a unique combination of depth, temperature, hydraulic and landscape classifiers. Using a combination of statistical analysis, published knowledge and expert opinion we selected representative variables and ecologically relevant thresholds and combined them geographically to form 87 Aquatic Ecological Units (AEU) types in the basin. The distribution of the 87 AEU types varied by lake and ecological zone with diversity highest Lake Huron, followed by lakes Michigan and Ontario, and lakes Superior and Erie have the fewest numbers of AEU types. This ecological classification and mapping represent a first-cut approximation of ecological patterns defined by physical factors that constrain ecosystem function in the Great Lakes aquatic ecosystem.
Keywords: Habitats, Classification, Ecosystem modeling, GIS.

RITCHIE, S.D.[1], MANDRAK, N.E.[1], CADOTTE, M.W.[1], and LENTINI, A.M.[2], [1]University of Toronto Scarborough, 1265 Military Trail, Toronto, ON, M1C1A4, CANADA; [2]Toronto Zoo, 361A Old Finch Ave, Toronto, ON, M1B 5K7, CANADA. **Overwintering Ecology of Head-started *Emydoidea blandingii* Turtles in an Artificial Wetland.**

The Blanding's Turtle (*Emydoidea blandingii*), a Threatened species in Canada, is expected to become extirpated in urban environments, such as the Greater Toronto Area, unless recovery actions are implemented. The Toronto Zoo's Adopt-A-Pond Wetland Conservation Programme has been supplementing the existing Blanding's Turtle population in Rouge National Urban Park (RNUP) with two-year old juveniles "head-starts", in an artificial wetland complex.The objective of this project is to determine the location of overwintering sites used by the head-starts, and examine the relationship between site selection, survival, and environmental variables. Environmental variables included water, ice,

soil and vegetation condition, pond size, and distance to land. These variables directly influence the physiological conditions and survival of overwintering turtles. The selection and availability of appropriate overwintering sites can minimize threats, such as acidosis and tissue freezing. Preliminary findings show the head-starts are using overwintering sites similar to their wild counterparts, and that temperature and dissolved oxygen content may play an important role in their survival. The results of this research will provide important insight for future wetland restoration design and turtle population supplementation programs. *Keywords: Wetlands, Blanding's Turtles, Head-starts.*

ROBERTSON, D.M.[1], SAAD, D.A.[1], BENOY, G.[2], VOUK, I.[3], JENKINSON, W.[2], BURCHER, R.S.[3], and JOHNSTON, C.M.[4], [1]U.S. Geological Survey Wisconsin Water Science Center, 8505 Research Way, Middleton, WI, 53562, USA; [2]International Joint Commission, Canadian Section, 234 Laurier Ave. West, Ottawa, ON, K1P 6K6, CANADA; [3]National Research Council of Canada, 1200 Montreal Road, Ottawa, ON, K1A 0R6, CANADA; [4]U.S. Geological Survey New England Water Science Center, 331 Commerce Way, Pembroke, NH, 03275, USA. **Binational SPARROW Watershed Modeling of the Entire Great Lakes Basin.**

Many eutrophication problems in the Great Lakes are caused by nutrient inputs from various interjurisdictional governances. Therefore, in developing nutrient protection and restoration plans, it is important to understand where the nutrients originate and the contributions from each governance. As part of a binational effort, new SPARROW (SPAtially Referenced Regression On Watershed attributes) models were developed to simulate phosphorus (P) and nitrogen (N) loading in streams throughout the entire Great Lakes basin; previous SPARROW models only simulated U.S. contributions. The new models cover the entire basin at higher resolution (~2 km2 catchments) enabling improved descriptions of the major locations and sources of P and N. The new models were developed using harmonized geospatial datasets describing the streamflow network, nutrient sources (location and quantity), and the environmental characteristics affecting nutrient delivery. The models were calibrated using loads sites monitored by U.S. and Canadian organizations. Model results are being used to: 1) estimate the P and N input to each Great Lake; 2) compare loading and yields from various tributaries and governances; and 3) estimate the relative importance of each nutrient source, including the upstream lakes. *Keywords: Watersheds, Nutrients, Pollution load.*

ROBICHEAU, S., ISAAC, J.L., and SHAW, C., Environmental Commissioner of Ontario, 1075 Bay Street, Suite 605, Toronto, ON, M5S 2B1, CANADA. **A Review of Ontario's Source Protection Planning Program 10 years into the Clean Water Act.**

Ontario's source water protection framework takes a local, watershed-based approach to developing source protection plans for most municipal drinking water sources across the province. Provincial law requires local planning committees to use a science-based approach to understand the unique water availability and water needs of an area, identify and characterize the existing and potential threats to sources of drinking water in that area, and develop policies to manage those threats. As of 2016, all source protection plans are now in effect and the Environmental Commissioner of Ontario - the province's legally mandated environmental watchdog - recently concluded a review of selected plans and their implementation to date. With a particular focus on plans that govern Great Lakes intakes, this presentation will identify some of the key policy trends across the plans, as well as some unique local approaches to protecting source water, highlighting lessons learned. It will also discuss some of the gaps in protection that remain and how they could be remedied through future policy changes. *Keywords: Drinking water, Source water, Water quality, Planning.*

RODGERS, T.F.M.[1], TRUONG, J.[1], JANTUNEN, L.M.[2], HELM, P.[3], and DIAMOND, M.L.[4], [1]Department of Chemical Engineering and Applied Chemistry, University of Toronto, Canada, 200 College St., Toronto, ON, M5S3E5, CANADA; [2]Centre for Atmospheric Research Experiments, Environment and Climate Change Canada, 4905 Dufferin St., Toronto, ON, M3H5T4, CANADA; [3]Environmental Monitoring and Reporting Branch, Ontario Ministry of Environment and Climate Change, 125 Resources Rd, Toronto, ON, M9P3V6, CANADA; [4]Department of Earth Sciences, University of Toronto, Canada, 22 Russel Street, Toronto, ON, M5S3B1, CANADA. **Organophosphate Ester Transport, Fate and Emissions in Toronto, using the Multimedia Urban Model.**

Organophosphate Esters (OPEs) are found at relatively high levels as environmental contaminants in the Great Lakes area. The usage of OPEs as flame-retardants has increased following the control of penta- and octa- BDEs as POPs under U.S., Canadian and international actions. We used the Multimedia Urban Model of Diamond and co-workers to estimate the emissions, transport and fate of three chlorinated (Cl-) and three non-chlorinated (non-Cl-) OPEs: TCPP, TCEP, TDCPP, EHDPP, TBEP and TPhP. Aggregate emissions to urban air were estimated by back-calculating from measured air concentrations. Model results were evaluated against measured water concentrations in Toronto tributaries. Modelled water concentrations were within an order of magnitude of those measured. Since the air and water concentrations were measured independently, this showed that the emissions estimates are likely reasonable to within an order of magnitude. OPE emissions ranged from 33 - 220 g/h, significantly higher than the emissions of PCBs and PBDEs calculated using the same model. 11 and 4% of Cl- and non-Cl-OPE emissions to air are transferred to Lake Ontario through river runoff. These estimates are consistent with the hypothesis of long-range transport of Cl-OPEs to the Arctic by rivers. *Keywords: Urban watersheds, OPEs, Modeling, Mass balance.*

ROONEY, R.C., ROBICHAUD, C.D., YUCKIN, S., and HOWELL, G., University of Waterloo, 200 University Ave W, Waterloo, On, N2L3G1, CANADA. **Can we restore ecological integrity by controlling Phragmites australis.**

Invasive *Phragmites australis* (common reed) degrades Great Lakes coastal marshes, reducing not only plant diversity and habitat heterogeneity, but altering edaphic conditions and ecosystem processes. The host of habitat changes in marshes where common reed has reached the "landscape spread" stage of invasion amount to a reduction in ecological integrity. Most post-control monitoring programs, however, focus only on the eradication of common reed and few have investigated whether its elimination results in the recovery of ecological integrity in treated marshes. We report preliminary results of our monitoring efforts that highlight the resilience of these valuable coastal marsh ecosystems following common reed treatment with the herbicide glyphosate. Following herbicide application in Long Point, on the north shore of Lake Erie, we monitored changes in plant community, primary productivity, and decomposition rates. We report on the short-term efficacy of herbicide-based treatment at reducing common reed and restoring ecological integrity.
Keywords: Biological invasions, Coastal marsh, Biomonitoring, Common Reed, Ecosystem health.

ROOSTAEI, J., ZHANG, Y., PITTS, D.K., and MCELMURRY, S.P., Wayne State University, 5050 Anthony Wayne Dr., Detroit, MI, 48202, USA. **Comparing the Removal Efficiency of 4-Nonylphenol by UV, Chlorination and Algae Cultivation.**

Nonylphenol ethoxylates are largely used for various industrial and household applications. After degradation, these chemicals produce endocrine disrupting compounds (EDCs) such as 4-Nonylphenol (4-NP). This research evaluated the removal efficiency of 4-NP by three different methods, UV treatment, chlorination disinfection, and algae treatment. UV and chlorination disinfection methods are considered in this research because of their vast applications in wastewater treatment plants (WWTPs). The removal efficiency of these two methods are compared with application of algae cultivation. COMBO water has been used as the medium, and the efficiency of removal (for two concentrations of 100 ug/L and 500 µg/l) has been evaluated by using LCMS and optical tracking of Daphnia's behavior. Primary results show that algae can remove 4-NP more effectively in comparison with UV. The results of chlorination experiment are not satisfying due to the high mortality rate of Daphnia, mainly as a result of chlorination agent effect and the level of the pH. These findings show algae cultivation which is proposed for wastewater treatment and biofuel production can be used for some EDCs removal such as 4-NP. Key Words: 4-Nonylphenol

Removal, Chlorination, UV, Algae Cultivation, Daphnia, EDCs *Keywords: Water quality, Endocrine disruption, Bioindicators.*

ROSEMAN, E.F.[1], FISCHER, J.L.[2], MIFSUD, D.[3], IRELAND, S.A.[1], DEBRUYNE, R.[2], FOOSE, M.[4], ELLISON, R.[5], MAYER, C.M.[2], KENNEDY, G.[1], JACKSON, S.A.[1], and PROVO, S.[2], [1]USGS Great Lakes Science Center, Ann Arbor, MI, USA; [2]University of Toledo, Toledo, OH, USA; [3]Herpetological Resource Management, Chelsea, MI, USA; [4]4Department of Environmental Quality, Office of the Great Lakes, Lansing, MI, USA; [5]US EPA, Grosse Ile, MI, USA. **Evaluating Shallow Water Habitat Restoration in the St. Clair River.**

Loss of shallow water riparian zones in the St. Clair River has reduced the availability of nursery areas and refuge for fishes. Restoration projects carried out along the river's U.S. bank are key to increasing critical shallow water habitat and evaluations were conducted to aquatic organism's response to restored shorezones. However, restoration sites are physically distinct and deployment of many standard gears is unfeasible at some sites, necessitating use of different suites of gears at different sites. A non-standard multifaceted sampling strategy was used to target multiple fishes and life stages. Sampling included egg pumping and egg mats to assess fish spawning, light traps targeting larval fish, and collections of juvenile and adults with minnow traps, backpack electrofishing, and gillnets at restoration and control sites. Few eggs were collected and invasive gobies dominated larval fish samples. However, native species in spawning condition were collected with all other gears at restoration and control sites. Multiple life stages of native fishes, including sportfish (e.g. yellow perch) and sensitive species (e.g. pugnose minnow), were observed at restoration and control sites, indicating the fish community is using these sites as nursery, refuge, and foraging areas. *Keywords: Shore protection, Habitats, Coastal ecosystems.*

ROWE, M.D.[1], ANDERSON, E.J.[2], RUBERG, S.A.[2], MOEGLING, S.[3], VERHAMME, E.M.[4], BELETSKY, D.[1], ZHANG, H.[1], JOHENGEN, T.H.[1], and STOW, C.A.[2], [1]Cooperative Institute for Limnology and Oceanography, University of Michigan, 4840 S. State Rd., Ann Arbor, Mi, 48108, USA; [2]NOAA Great Lakes Environmental Research Lab, 4840 S. State Rd., Ann Arbor, MI, 48108, USA; [3]City of Cleveland Division of Water, 1201 Lakeside Ave., Cleveland, OH, 44114, USA; [4]LimnoTech, 501 Avis Drive, Ann Arbor, MI, 48108, USA. **Modeling Dissolved Oxygen Dynamics Near Drinking Water Intakes in the Central Basin of Lake Erie.**

Lake Erie provides drinking water to 11 million people through >30 public water systems (PWS). Lake dynamics, including seiche, internal waves, and wind-induced upwelling-downwelling, can cause changing water quality at intakes over a period of a few hours. Treatment processes may need to be adjusted in response to changes in temperature, dissolved oxygen (DO), pH, organic matter, iron, or manganese; thus, PWS operators could benefit from a forecast of events that are likely to produce changes in source water quality at their intakes. In 2016, an updated Lake Erie Operational Forecast System (LEOFS), using the Finite Volume Community Ocean Model, became operational, providing nowcast and 120 hour forecast of 3-D currents and temperature. We linked the LEOFS model to a simple DO model that included 3-D advection-diffusion, exchange with the atmosphere, consumption of oxygen at the sediment surface, and by reduced substances released from the sediment. Modeled hypoxia initiated in mid July or early August and continued until late September, and initiated earlier at the shallower station, consistent with observations. Observed interruptions in hypoxia were associated with the epilimnion contacting the bottom. We evaluated the sensitivity of simulated hypoxia to varying parameter values in the DO model. *Keywords: Lake Erie, Hypoxia, Hydrodynamic model, Drinking water.*

ROZON, R.M., BOWEN, K.L., NIBLOCK, H.A., FITZPATRICK, M.A., and CURRIE, W.J.S., Fisheries and Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7S 1A1, CANADA. **Assessment of the Phytoplankton and Zooplankton Populations in the Niagara River Area of Concern.**

There is little known about the plankton communities of the Niagara River connecting channel, though it joins the well-studied Lakes Erie and Ontario. In the first complete plankton survey in the area, three sites above Niagara Falls and three below were sampled monthly for water chemistry, phytoplankton and zooplankton composition from June to October 2014. The Niagara River exhibited the conditions of a low-productivity, oligotrophic, clear-phase system. Phytoplankton biomass was low (<0.5 g/m^3) and dominated by diatoms, including species of *Fragilaria* and *Skeletonema* that are suited to high-energy flow. The summer zooplankton community was numerically dominated by dreissenid veligers whereas biomass was comprised mostly of calanoid copepods, which are known to withstand high flow. Zooplankton densities decreased exponentially with distance from Lake Erie, with a small increase below the hydroelectric reservoirs; reduced densities of phytoplankton and zooplankton are expected when transitioning to high flow riverine environments. We assess the structure and dynamics of planktonic communities within the Niagara River and explore some of the key physical and biological factors which affect their distribution, including mortality, residence times and refugia within the hydroelectric reservoirs. *Keywords: Niagara River, Phytoplankton, Zooplankton.*

RUBERG, S.A.[1], CONSTANT, S.A.[1], MUZZI, R.W.[1], MILLER, R.J.[2], and SMITH, J.P.[2], [1]NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Rd., Ann Arbor, MI, 48108-9719, USA; [2]CILER, G110 Dana Building 440 Church Street, Ann Arbor, MI, 48109-1041, USA. **Utilization of PostgreSQL Database for Real-Time Western Lake Erie Data Storage and Dissemination.**

In August 2014, a harmful algal bloom (HAB) contaminated the water supply of Toledo, OH, leaving over 400,000 residents without drinking water for 2 days. Real-time observations of temperature, HAB-related optical parameters (chlorophyll, phycocyanin, turbidity) and nutrients (phosphorus, nitrogen) are important components of HAB modeling and forecasting efforts serving Lake Erie drinking water managers but have been traditionally stored in plain-text format, representing a data management challenge. The current setup does not allow for expedient querying, analysis, or quick visualization of parameters of interest. We present an improved setup through the utilization of the robust and industry standard PostgreSQL database management system to store and disseminate real time buoy data from Western Lake Erie. A setup that provides a workflow that receives the data from a station or buoy, and executes quality checks against the data, storing the results in the database, will be discussed. Lastly, an interface to the data for use by water managers and other stakeholders will be presented. *Keywords: Data acquisition, SQL, Data storage and retrieval, Databases.*

RUPASINGHE, P.A., MARCACCIO, J.V., MARKLE, C.E., and CHOW-FRASER, P., McMaster University, Department of Biology, 1280 Main St. West, Hamilton, ON, L8S 4K1, CANADA. **Determining the best time to map invasive Phragmites in wetlands using time series analysis.**

Phragmites australis subspecies *australis* (European common reed) has become one of the worst invaders in wetland ecosystems of North America. This plant has spread into tidal and non-tidal habitats, displacing native plants in many parts of Canada and all 48 contiguous states of the USA. Using remotely sensed data to map P. australis allows managers to detect plant distributions in relatively large areas with complex geographic terrain, even when they are inaccessible for field surveys. Due to dynamic water levels and high vegetation diversity, mapping invasive P. australis is challenging in coastal wetlands of the Laurentian Great Lakes. When mapping the distribution of a single species, species-specific attributes such as canopy architecture, vegetative density, leaf pubescence and phenological stage are capable of producing a unique spectral signature that can be detected through remote sensing platforms. We will use space borne, multispectral time series data to investigate the best phenological state of P. australis that will produce the most identifiable reflectance signature which will allow us to determine the best time of the year for mapping this invasive species. *Keywords: Remote Sensing, Phragmites, Time series.*

RUSZAJ, A., IDNR - Coastal Management Program, 160 N. La Salle St, Suite S-703, Chicago, IL, 60660, USA. **Progress in Removing Beneficial Use Impairments in Waukegan Harbor Area of Concern.**

Waukegan Harbor is the only Area of Concern (AOC) in Illinois, with six Beneficial Use Impairments (BUIs) originally designated in the AOC. Multiple partners have been involved in the AOC clean-up and significant progress has been made towards removing the impairments. This presentation will provide an update on progress that has been made in removing the BUIs. Three BUIs (beach closings; loss of fish and wildlife habitat; restrictions on dredging activity) have been removed while the remaining three (degradation of benthos; degradation of phytoplankton and zooplankton; restrictions on fish and wildlife consumption) are being monitored to determine response after final clean-up actions. We will discuss partnerships and coordination among various agencies, outcomes achieved to-date, challenges faced along the way, and future work planned for monitoring the remaining BUIs. *Keywords: Area of Concern, Beneficial Use Impairments.*

RUTHERFORD, E.S.[1], GEFFEN, A.J.[2], NASH, R.D.M.[3], WELLS, D.J.[4], GLYSHAW, P.[4], VANDERPLOEG, H.A.[1], CAVALETTO, J.F.[1], and MASON, D.M.[1], [1]NOAA GLERL, 4840 S. State Rd, Ann Arbor, MI, 48108, USA; [2]University of Bergen Dept. Biology, Bergen, NORWAY; [3]Institute of Marine Research, Nordnesgaten 33/PB 1870 Nordnes, Bergen, 5817, NORWAY; [4]University of Michigan CILER, 4840 S. State Rd, Ann Arbor, MI, 48108, USA. **Have Invasive Species Caused Changes in Larval Fish Density and Distribution in SE Lake Michigan?**

The decline in Lake Michigan's pelagic prey fish biomass since the early 1980s was coincident with declining nutrient loads, food web disruption by invasive species (AIS), and variable piscivore predation. We hypothesized that biomass declines of adults also may be related to AIS effects on fish larvae. We compared densities and distributions of larval fish and zooplankton sampled monthly from April-September at a nearshore to offshore transect in SE Lake Michigan in 1983 with those sampled monthly at a nearby transect in 2010 and 2015. Compared to 2010 and 2015, densities of deepwater sculpin (DWS), bloater (BLT), and rainbow smelt (RBS) larvae all were much higher in 1983, but alewife (ALE) larvae were equally dense in both time periods. Depth-stratified sampling indicated that in 1983, BLT larvae were most dense in the epilimnion but in 2010 and 2015 were most dense in the metalimnion. Possible causes of changes in larvae density and vertical distribution offshore include: increased water clarity, owing to Dreissena-mediated reductions in plankton biomass and production, and decreased densities of planktivorous ALE and RBS adults, which facilitated expansion and predation by the visually preying Bythotrephes on epilimnetic zooplankton composition and abundance, resulting in their redistribution to deeper waters. *Keywords: Invasive species, Bloater, Lake Michigan, Fish larvae, Distribution patterns.*

RUTTER, J.E., University of Minnesota - Twin Cities, 2003 Upper Buford Circle, Skok 135, St. Paul, MN, 55108, USA. **Using Social Media at Scientific Conferences, A Case Study of NAOC 2016.**

Social media is a currently underutilized networking tool by science conferences, which has the ability to maximize the benefits of the event for both organizers and attendees. Twitter specifically is set up in a way that allows constant and continual sharing of information. This medium provides an optimal platform for organizers to communicate with the public (attendees or not) about the conference before, during, and after the event. Twitter also allows people to report live about program items such as symposia talks, workshops, socials, and more. In doing so not only are the attendees connecting with others present but are also spreading that information to people around the world. By using social media to talk about the conference, science in general is getting discussed more as well. New projects and collaborations are all possibilities and results of using social media in general but especially at conferences. The North American Ornithological Conference (NAOC) that took place in 2016 is a case study that demonstrates the additional success scientific conferences can have when social media is incorporated. *Keywords: Outreach, Social Media, Public education, Science Communication, #SciComm.*

RUZICH, J.K.[1], LARSON, W.A.[2], TURNQUIST, K.N.[1], NYE, N.J.[3], and ROWE, D.C.[4], [1]Wisconsin Cooperative Fishery Research Unit, University of Wisconsin-Stevens Point, 800 Reserve St., Stevens Point, WI, 54481, USA; [2]U.S. Geological Survey, Wisconsin Cooperative Fishery Research Unit, 800 Reserve St., Stevens Point, WI, 54481, USA; [3]Wisconsin Department of Natural Resources, N3344 Stebbins Rd., Poynette, WI, 53955, USA; [4]Wisconsin Department of Natural Resources, 3911 Fish Hatchery Rd., Fitchburg, WI, 53711, USA. **Genetic Assessment of Seven Fish Species Above and Below the Prairie du Sac Dam.**

The Prairie du Sac dam is the last impassable structure on the Wisconsin river before convergence with the Mississippi river. Reductions in connectivity caused by this artificial barrier could influence the genetic diversity of isolated subpopulations and reduce their ability to adapt to selective pressures. The objective of our project is to determine if genetic structure and/or differences in diversity exist between populations of fish found above and below the Prairie du Sac dam. We analyzed seven fish species with varying life history traits and generation times: lake sturgeon (Acipenser fulvescens), walleye (Sander vitreus), sauger (Sander canadensis), smallmouth bass (Micropterus dolomieu), flathead catfish (Pylodictis

olivaris), shorthead redhorse (Moxostoma macrolepidotum), and quillback carpsucker (Carpiodes cyprinus). Sampling occurred over two years, and fifty samples above and below the dam were collected for each species in each year (1,400 samples total). Genetic diversity and population structure was evaluated for each species using a minimum of eight microsatellites. The results of this project will provide resource managers with baseline genetic information that can be used to develop management strategies, such as fish passage, that will preserve the genetic integrity of populations within the Wisconsin River.
Keywords: Genetics, Dams, Fisheries.

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SAAVEDRA, N.E.[1] and PATERSON, G.[2], [1]SUNY College of Environmental Science and Forestry, 1 Forestry Dr., Syracuse, NY, 13210, USA; [2]Michigan Technological University, 1400 Townsend Dr., Houghton, MI, 49931, USA. **Quantifying Lake Ontario lake trout responses before, during, and after the Ponto-Caspian invasion.**

While successful lake trout (Salvelinus namaycush) restoration efforts have been documented in some regions of the Great Lakes, the Lake Ontario population continues to be primarily supported by stocking efforts. Given current knowledge linking invasive Ponto-Caspian species to effects on nutrient and energy cycling in Great Lakes food webs, it is probable that these species have changed the foraging ecologies of top predators and their capacity to acquire and assimilate prey energy from this changed food web. Using long-term biomonitoring data collected from 1977-2014, we aim to address changes in growth, condition, and persistent organic pollutant (POP) bioaccumulation in lake trout during the timeframes prior to, during, and following dreissenid mussel (Dreissena spp.) and round goby (Neogobius melanostomus) establishment in Lake Ontario. POP bioaccumulation serves as a novel measure of lifetime resource consumption and can also provide valuable information on predator gross growth efficiencies. Lake Ontario lake trout have experienced changes in growth and condition following the Ponto-Caspian invasions. This study demonstrates the use of POP bioaccumulation as an accurate tracer of resource consumption and provides detailed information regarding Lake Ontario lake trout responses to the re-engineering of their food web. *Keywords: Lake trout, Bioenergetics, Environmental contaminants.*

SAFAIE, A.[1], CURTIS, Z.K.[1], QIU, H.[1], LIAO, H.S.[1], LI, S.G.[1], LITCHMAN, E.[2], and PHANIKUMAR, M.S.[1], [1]Department of Civil and Environmental Engineering, Michigan State University, East Lansing, MI, 48824, USA; [2]Kellogg Biological Station, Michigan State

University, Hickory Corners, MI, 49060, USA. **The importance of groundwater-lake interactions on stratification in a deep inland lake.**

We evaluate the role of groundwater on thermal structure and circulation in Gull Lake, a deep inland lake in Michigan, USA. Gull Lake is a groundwater-fed lake with bottom cooling and strong stratification during summer. A coupled atmosphere-surface water-groundwater model has been developed to investigate physical processes in the lake during the summer stratified period. High-resolution current observations, lake levels, and temperature data were used to test the numerical models. The hydrodynamic model of the lake has been developed based on a three-dimensional, unstructured grid Finite-Volume Community Ocean Model (FVCOM). A network of weather stations surrounding the lake was used to reconstruct meteorological forcing over the lake. To assess the quality of the reconstructed meteorological data, a mesoscale numerical weather forecasting model (WRF) were utilized. Streamflow and groundwater recharge in the lake's watershed were simulated using an integrated, process-based hydrologic model. Groundwater-lake interactions were simulated by integrating a three-dimensional groundwater flow model with the lake model to quantify the flux of water through the bottom of the lake. Results illustrate the significant improvement in describing the thermal structure of Gull Lake associated with groundwater exchange. *Keywords: Lake model, Stratification, Hydrodynamic model, Vertical mixing, Atmosphere-lake interaction, Groundwater.*

SALAMOVA, A.[1], PEVERLY, A.A.[2], VENIER, M.[1], and HITES, R.A.[1], [1]Indiana University, 702 N Walnut Grove Ave, Bloomington, IN, 47405, USA; [2]Eureka College, Eureka, IL, 61530, USA. **Spatial and Temporal Trends of Particle Phase Organophosphate Ester Concentrations in the Atmosphere.**

The concentrations of six organophosphate esters (OPEs) were measured in atmospheric particle phase samples collected once every 12 days at five sites in the North American Great Lakes basin over the period of March 2012 to December 2014. These OPEs include: tris(2-chloroethyl) phosphate (TCEP), tris(2-chloroisopropyl) phosphate (TCIPP), and tris(1,3-dichloroisopropyl) phosphate (TDCIPP), tri-n-butyl phosphate (TNBP), triphenyl phosphate (TPHP), and 2-ethylhexyl diphenyl phosphate (EHDP). Median total OPE concentrations ranged from 93 pg/m3 at Sleeping Bear Dunes to 1050 pg/m3 at Chicago. The total OPE levels were significantly ($P < 0.05$) higher at Chicago and Cleveland, our urban sites, than at our rural and remote sites. The composition profiles were dominated by chlorinated OPEs at the urban and rural sites and by non-chlorinated OPEs at the remote sites. The concentrations of all OPEs were significantly ($P < 0.001$) correlated to one another, suggesting that these compounds share similar sources. Most atmospheric total OPE concentrations were significantly ($P < 0.05$) decreasing over time, with halving times of

about 3.5 years at the urban sites and about 1.5 years at the rural and remote sites. *Keywords: Environmental contaminants, Organic compounds, Great Lakes basin.*

SALK, K.R.[1], BULLERJAHN, G.S.[2], MCKAY, R.M.L.[2], CHAFFIN, J.D.[3], and OSTROM, N.E.[1], [1]Michigan State University, 288 Farm Lane, Rm 203, East Lansing, MI, 48824, USA; [2]Bowling Green State University, 217 Life Science Building, Bowling Green, OH, 43403, USA; [3]Stone Laboratory Ohio Sea Grant, 878 Bayview Ave, Put-In-Bay, OH, 43456, USA. **Dramatic Shifts in Nitrogen Cycling in Sandusky Bay, Lake Erie: Effects on HABs and Nitrogen Loading.**

While much of the focus on the control of offshore HABs in Lake Erie is on phosphorus (P) management, nearshore areas such as Sandusky Bay become seasonally limited by nitrogen (N) and are characterized by distinct HAB compositions dominated by *Planktothrix*. We hypothesized that microbial N loss processes drive rapid N depletion in Sandusky Bay, and N limitation stimulates N fixation that supports HAB persistence. Stable isotope tracer approaches were employed to quantify rates of denitrification, anammox, N2O production, and N fixation. During periods of high discharge and nutrient delivery from the Sandusky River, Sandusky Bay acted as a conduit for nutrient loading into Lake Erie, which could stimulate offshore HABs. This period was also exemplified by high N2O emissions from the Bay, as substrates for denitrification and nitrification were abundant. As water residence time increased throughout the season, N loss processes drove marked decreases in nitrate. Denitrification, anammox, and N2O production made up 84, 14, and 2 % of total N loss. N fixation was active under N limitation, representing bioavailable N generation that could indirectly support HABs in late summer. The dramatic shifts in N availability observed in Sandusky Bay can inform management of HABs and N2O production in Lake Erie. *Keywords: Nitrous oxide, Harmful algal blooms, Nitrogen, Nutrients, Stable isotopes.*

SALO, M.[1], BOCKWOLDT, K.A.[1], STETTNISCH, M.N.[1], SUCHOCKI, C.R.[1], NEUVILLE, K.P.[1], GRUNDL, T.J.[1], KLUMP, J.V.[1], KASTER, J.L.[1], and MAAS, M.[2], [1]University of Wisconsin- Milwaukee, Milwaukee, WI, 53202, USA; [2]COBACH, Bacalar, MEXICO. **Hydrologic Budgets and Salinity Gradients in Fault Controlled Lakes, Yucatan, Mexico.**

Laguna Bacalar is Mexico's second largest freshwater lake located in the southern Yucatan Peninsula. The lake is located in a north south controlled fault that parallels the coastline 72 km from the open ocean. Simple water quality parameters (pH, specific conductivity, temperature) were collected from influent springs, the open lake, and Laguna Guerrero - a similar fault controlled lake located 20 km from the shore - and the ocean at

Chetumal Bay. A salinity gradient from 13850 uS/cm (Chetumal Bay) to 5790 uS/cm (Laguna Guerro) to 2265 uS/cm (Laguna Bacalar) was observed. Laguna Bacalar water chemistry is dominated by calcium, magnesium, and bicarbonate and has high silica concentrations. Depth profiles of dissolved oxygen, temperature, and pH were collected in three deep (50 m) cenotes. Each cenote displays different profiles indicative of differing relationships with the groundwater. The hydrologic budget is dominated almost entirely by groundwater inflow/outflow. The single small outlet stream of Laguna Bacalar was gauged, and a maximum residence time of 2 years was calculated. Influent water appears to be dominated by groundwater input at the southern end of the lake where large cenotes are evident. *Keywords: Gages, Hydrologic budget, Water quality.*

SARD, N.M.[1], ROBINSON, J.D.[1], HERBST, S.J.[2], and SCRIBNER, K.T.[3], [1]Fisheries and Wildlife Department, Michigan State University, East Lansing, MI, 48824, USA; [2]Department of Natural Resources, Lansing, MI, 48913, USA; [3]Department of Integrative Biology, Michigan State University, East Lansing, MI, 48824, USA. **Testing vectors to explain how Round Goby colonized inland lakes and rivers using genomics data.**

In the early 1990s, the Round Goby (*Neogobius melanostomus*) invaded Lake St. Clair and quickly spread throughout the Great Lakes. More recently, Round Gobies have colonized inland lakes and rivers in adjacent states, including Michigan. Paradoxically, some of the newly colonized locations are above large dams. Potential explanations for these colonization events include 1) natural dispersal from Great Lakes tributaries, 2) movement via local angler collections, and 3) spread by the commercial bait industry. In 2016, we collected tissue samples (25 ± 1, mean ± SD) from 21 locations, including 9 potential Great Lakes sources and 12 inland rivers/lakes. We used Restriction site Associated DNA sequencing (RAD-seq) to genotype all samples at thousands of SNP loci. Using an approximate Bayesian computation framework, measures of genetic diversity within, and variance among locations, were used to test several alternative hypotheses to determine the most likely mode of colonization of inland rivers and lakes. Estimates of founding source, founding number, and timing of introduction, as well as the degree of concordance across multiple inland sites, will inform management to curtail future infestations of aquatic invasive species with similar introduction pathways and potential for spread. *Keywords: Round goby, Colonization, Invasive species, RAD-seq, Approximate Bayesian computation.*

SARD, N.M.[1], HERBST, S.J.[2], UHRIG, G.[3], KANEFSKY, J.[1], and SCRIBNER, K.T.[4], [1]Fisheries and Wildlife Department, Michigan State University, East Lansing, MI, 48824, USA; [2]Department of Natural Resources, Lansing, Mi, 48913, USA; [3]University of Wisconsin-Milwaukee, Milwakee, WI, 53211, USA; [4]Department of Integrated Biology, Michigan State University, East Lansing, MI, 48824, USA. **Comparing eDNA and traditional surveys of diversity and abundance: implications for invasive fishes.**

Detecting an aquatic invasive species before they become established within a lake or stream is crucial for effective management. Yet, detecting any species at low abundance using traditional sampling methods can be difficult. Environmental DNA (eDNA) sampling methods effectively detect species at low abundance, however, most assays only detect a single species. Here, we used eDNA and a metabarcoding approach to characterize entire fish communities. In 2016, Michigan's Department of Natural Resources (MDNR) sampled eight lakes using traditional gear types, as part of their Status and Trends survey to characterize fish communities. In concert, we collected 50 ± 8 (mean ± SD) water samples from each lake. We used next-generation sequencing technology to identify all fish specific 12S and 16S barcodes within extracted eDNA samples. Fish species were identified by comparing barcodes to a database we developed that contained Michigan fishes. To evaluate how effective eDNA sampling was at characterizing entire fish communities, we compared eDNA measures of diversity, species prevalence, and rates of occupancy to estimates based on traditional sampling methods. We conclude that eDNA sampling is an effective tool to identify low abundance species, including nascent invaders, and improves estimates of fish community diversity. *Keywords: Invasive species, Environmental DNA, Fish, Early dectection, Metabarcoding.*

SAWTELL, R.W.[1], SAYERS, M.J.[1], SHUCHMAN, R.A.[1], BOSSE, K.R.[1], HART, B.E.[1], and LEKKI, J.[2], [1]Michigan Tech Research Institute, 3600 Green Court, Suite 100, Ann Arbor, MI, 48105, USA; [2]NASA Glenn Research Center, 21000 Brookpark Road, Cleveland, OH, 44135, USA. **Near Real Time HABs Observations in Lake Erie Using a Lightweight Portable Radiometer.**

Harmful Algae Blooms (HABs) are an ongoing water quality concern for water treatment management in Lake Erie and involve both remote and direct sensing of water conditions throughout the HABs season. As part of a multi-institutional collaboration with NASA, an inexpensive, Lightweight Portable Radiometer (LPR) system was built using commercial off the shelf parts. This system is used to perform near real time hyperspectral radiance and irradiance measurements at a remote location accessible only by boat in the Western Basin of Lake Erie. Sampling frequency is on sixty second intervals for up to several hours per day, daily, for a period of over three months. Observations from this system reveal daily and seasonal variations in atmospheric and water quality conditions, including highly local HABs surface scum. *Keywords: Harmful algal blooms, Remote sensing, Lake Erie.*

SAYERS, M.J.[1], RUBERG, S.[2], LESHKEVICH, G.[2], STUART, D.G.[3], SHUCHMAN, R.A.[1], and ADEN, S.T.[1], [1]Michigan Tech Research Institute, Michigan Technological University, 3600 Green Ct., Ste. 100, Ann Arbor, MI, 48105, USA; [2]NOAA GLERL, 4840 S. State Rd., Ann Arbor, MI, 48108, USA; [3]Cooperative Institute for Limnology and Ecosystems Research (CILER), G110 Dana Building, 440 Church Street, Ann Arbor, MI, 48109, USA. **Spatial and Temporal Patterns of Inherent Optical Properties in Western Lake Erie for 2015 and 2016.**

Weekly measurements of inherent optical properties (IOPs) were made by NOAA/GLERL and MTRI at sites in western Lake Erie from May through October in 2015 and 2016. Water column IOP measurements of absorption and scattering were made using a WetLabs AC-S and BB-9 respectively. A Satlantic hyperspectral profiling radiometer was also deployed to measure water column reflectance and attenuation. Hyperspectral surface reflectance was also measured with a Satlantic Hypergun. Coincident water samples were collected and analyzed for concentrations of chlorophyll, phycocyanin, TSS, and CDOM absorption. These suites of measurements are invaluable for the calibration and validation of remote sensing water quality algorithms. The objective of collecting these time-series observations is to document the spatio-temporal variations in IOPs due to prolific blooms of harmful cyanobacteria (cyanoHABs) in Lake Erie. Significant differences in absorption spectra were observed throughout the observation period and between years. These observed differences are attributed to fluctuations in cyanoHAB extent and concentration but also from the periodic occurrence of large sediment plumes from the Maumee River. These measurements were able to capture the differences in IOPs resulting from a severe cyanoHAB event in 2015 and a mild event in 2016. *Keywords: Remote sensing, Harmful algal blooms, Water quality.*

SCHAEDING, Z.J.[1], BOZIMOWSKI, A.A.[2], UZARSKI, D.G.[2], and UZARSKI, R.L.[1], [1]Environmental Health and Safety Program, Dept. of Biology, and Dept. of Health Professions, Central Michigan University, Mt. Pleasant, MI, 48859, USA; [2]Institute for Great Lakes Research, CMU Biological Station, and Dept. of Biology, Central Michigan University, Mt. Pleasant, MI, 48859, USA. **An Analysis of Microcystin Concentrations in Great Lakes Coastal Wetlands.**

Development of harmful algal blooms in aquatic environments is typical of excessive nutrient loading that may promote the introduction of microcystins. Microcystins pose a threat to human health. The intent of this study was to explore relationships between microcystins and concentrations of dissolved and total nitrogen and phosphorus in Great Lakes coastal wetlands. Twenty-eight water samples were collected from Great Lakes coastal wetlands of Lakes Erie, Huron and Michigan as well as Lake St. Clair. The majority of

samples tested positive for microcystin concentrations but did not exceed the limit for safe drinking water established by the USEPA. Additionally, all but three samples contained nitrogen and phosphorus concentrations well below the ecoregional advisory thresholds established by USEPA. Pearson Correlation revealed significant relationships between microcystin concentrations and both nitrogen and phosphorus in Great Lakes coastal wetlands. However, -r values for TP and SRP were weak and TN was substantial (0.47, 0.43 and 0.76 respectively). It is unclear whether or not microcystins are being produced as a result of elevated TN or that the elevated TN is the result of nitrogen fixers associated with cyanobacteria that produce microcystins. *Keywords: Microcystis, Nutrients, Environmental health.*

SCHAFER, N. and CITRIGLIA, M., Northeast Ohio Regional Sewer District, 4747 East 49th Street, Cuyahoga Heights, OH, 44125, USA. **qPCR: A Screening Tool For Harmful Algal Blooms.**

Lake Erie has seen an increase in the number of HABs caused by cyanobacteria as well as in the severity of these blooms. The cyanobacteria present in the HABs can potentially produce toxins capable of causing illness and/or death. Timely and accurate identification and reporting of these toxins is critical for issuing water quality advisories. The analytical methods for toxin analysis are very expensive and selecting the correct analytical method can be difficult. Another challenge is the necessity for a skilled analyst available for microscopic algae identification. Furthermore, some cyanobacteria can produce multiple toxins. For example the genus Anabaena can produce anatoxin-a, saxitoxin, or microcystin and the genus Aphanizomenon can produce saxitoxin, anatoxin-a, or clylindrospermopsin. NEORSD decided to experiment with a rapid method utilizing Quantitative Polymerase Chain Reaction (qPCR) to screen for a total cyanobacteria gene and specific toxin producing genes (microcytins, saxitoxin, and cylindrospermopsin). The NEORSD laboratory experimented with the Phytoxigene, CyanoDTec qPCR assays as a means to screen samples submitted for cyanotoxin analysis. A portion of the sample submitted for analysis was filtered, and the DNA was extracted and analyzed on multiple qPCR pla *Keywords: Harmful algal blooms, Microcystis, Monitoring.*

SCHEPPLER, M.R.[1], SNYDER, M.R.[2], MARSHALL, N.T.[2], CZAJKOWSKI, K.P.[3], and STEPIEN, C.A.[4], [1]Bowling Green State University, Dept. of Biological Sciences, Bowling Green, OH, 43403, USA; [2]University of Toledo & NOAA PMEL, Dept. of Environmental Sciences, Toledo, OH, 43606, USA; [3]University of Toledo, Dept. Geography & Planning, Toledo, OH, 43606, USA; [4]NOAA PMEL, 7600 Sand Point Way NE, Seattle, WA, 98115, USA. **Identifying Species from Bait Shops: Potential Vectors for Invasives in the Great Lakes?**

Bait retailers along the Great Lakes are potential vectors for introductions of aquatic invasive species. We identifying fish species, including non-target and/or invasive taxa, sold by 46 bait shops from the Wabash River in Indiana to the western and southern coasts of Lake Erie. Bait was purchased, and morphologically identified and the eDNA from their water was extracted for later assessment of accompanying taxa. Just one invasive species was visually identified - goldfish *Carassius auratus*, and no non-target non-bait were observed (e.g., small walleye *Sander vitreus* or yellow perch *Perca flavescens*). The most commonly advertised bait fish were: emerald shiner *Notropis atherinoides*, golden shiner *Notemigonus crysoleucas* and fathead minnow *Pimephales promelas*. However, 17 samples contained non-target bait species (i.e., those unintentionally sold with the target species), which might indicate lack of awareness by retailers. Maumee Bay, Lake Erie stores had the fewest non-target bait species (1%). The Michigan region had the most (33%). Results augment knowledge about possible spread of invasive species, and study findings may be useful for developing best practices for retailers and managers. *Keywords: Invasive species, Bait shops, Fish, Retailers, Risks, Management.*

SCHLEA, D.A.[1], BELL, S.B.[1], BOLES, C.M.W.[1], VOORHEES, M.E.[2], CURRIE, S.J.[2], and FRIONA, A.M.[2], [1]LimnoTech, 501 Avis Drive, Ann Arbor, MI, 48108, USA; [2]U.S. Army Corps of Engineers, Buffalo District, 1776 Niagara Street, Buffalo, NY, 14207, USA. **Assessing the Large-Scale Feasibility of Wetlands as Agricultural BMPs.**

Innovative solutions to watershed scale pollution have been recommended to reduce harmful algal blooms traced to nonpoint source phosphorus runoff, which is a key priority of the Great Lakes Restoration Initiative. This presentation will describe an effort sponsored by the U.S. Army Corps of Engineers to compile information and advance understanding of the potential for wetlands as one such innovative solution. Included in the effort were a literature review that focused on wetland phosphorus removal effectiveness, development of a GIS methodology for site-selection, and an engineering evaluation. The engineering evaluation sought to assess the large-scale feasibility of wetlands as agricultural control measures and covered the following topics: major obstacles to the widespread use of wetlands as agricultural BMPs, critical design elements related to phosphorus removal effectiveness, operation and maintenance considerations, regulatory considerations, cost considerations, and relative advantages/disadvantages compared to other BMPs. This presentation will discuss these topics along with recommendations for the strategic use of wetlands as part of the solution to reducing nonpoint source phosphorus loading to the Great Lakes. *Keywords: Wetlands, BMPs, Phosphorus.*

SCHMIDT, M.L.[1], PROPS, R.[2], and DENEF, V.J.[1], [1]University of Michigan, Ann Arbor, MI, 48103, USA; [2]Ghent University, Ghent, BELGIUM. **Active and total bacterial communities differ along a near to offshore transect in Lake Michigan.**

Though bacteria play a fundamental role in freshwater biogeochemical cycling and community dynamics, they are often left out of Great Lakes studies. Typically, bacterial communities are censused via high throughput sequencing of the 16S rRNA gene, providing insights into the diversity of all potentially active and dormant bacteria at the DNA level. However, the influence of bacteria on ecosystem function is most likely predominated by active organisms. Here, we high throughput sequenced the 16S rRNA gene using simultaneously extracted DNA and RNA to evaluate the DNA versus the RNA community in samples collected monthly in 2015 from April until October along a eutrophic to oligotrophic transect in Lake Michigan. DNA and RNA samples differed in species presence/absence (14%) and, in line with previous studies, by species abundances (30%). Several microbial phyla differed between DNA and RNA samples and included five of the most abundant groups. Verrucomicrobia, Alpha-, and Beta-proteobacteria were overrepresented in the RNA pool while Actinobacteria and Bacteriodetes were overrepresented in in the DNA pool. These taxonomic differences between in the potentially active and total bacterial communities indicate that there may be multiple layers to the microbial communities that underpin lake community and ecosystem processes. *Keywords: Microbiological studies, Biodiversity, Observing systems.*

SCHNARS, J.L. and STILWELL, A.R., Regional Science Consortium, 301 Peninsula Drive, Erie, PA, 16505, USA. **Monitoring HABs in the Pennsylvanian Waters of Lake Erie.**

Harmful algal blooms (HABs) is a well known issue in the western basin of Lake Erie, however it also occurs in the central basin. The Regional Science Consortium (RSC) has been monitoring the waters of Lake Erie off the peninsula of Presque Isle State Park and Presque Isle Bay weekly for HAB toxins for the last three seasons. Using ELISA, analysis has been conducted on Microcystin, and intermittently on Anatoxin-a, Saxotoxin, and Cylindrospermopsin. The RSC works with PA DCNR and the Erie County Department of Health to implement action when concentrations of HAB toxins exceed thresholds. Although Microcystin concentrations have not exceeded human recreational water thresholds, they often exceed the thresholds for dogs. When the dog threshold is exceeded, the recommendation for waterfront managers is to post informational signage, however not all managers comply. We found when signage is posted, the public is not familiar with this issue resulting in the sign being ignored. In addition to water testing, the RSC continues to work with a variety of organizations and target audiences to create awareness of HABs and a mechanism to report a suspected HAB. *Keywords: Harmful algal blooms, Monitoring, Lake Erie.*

SCHNARS, J.L., Regional Science Consortium, 301 Peninsula Drive, Erie, PA, 16505, USA. **Overcoming Barotrauma in Lake Erie Yellow Perch.**

Yellow Perch inhabit deep (>20 meters) waters, making them vulnerable to acute decompression sicknesses or barotrauma. The mortality of a Yellow Perch released by an angler is assumed to be very high, however had not been quantified. Release rates reach 97,000 Yellow Perch annually in the Pennsylvanian waters of Lake Erie. Catch-release mortality is a management concern to Pennsylvania Fish and Boat Commission since fishery models currently assume no mortality of released fish. This study quantified different means of mortalities and investigated the outcome of two different release techniques: rapid descent cages, and an 18 meter vertical hoop net. Results revealed Yellow Perch have the ability to survive acute barotrauma if they are released at the surface or if quickly returned to depth; however survivability decreased later in the season when bottom water temperatures increased and dissolved oxygen decreased. Although Yellow Perch exhibiting barotrauma are capable of being released at the water's surface and are able to return to depth unaided, seagulls quickly consume any released fish. Additional studies will continue during the 2017 season to further investigate this research. *Keywords: Lake Erie, Barotrauma, Yellow perch.*

SCHNEEBERGER, P., Michigan Department of Natural Resources, Fisheries Division, 484 Cherry Creek Road, Marquette, MI, 49855, USA. **Tribute From a Tributary.**

Jim Diana has been my advisor, instructor, employer, collaborator, motivator, inspiration, teammate/opponent, and friend. He was my major professor for a Masters Degree. Career-wise, Jim hired me as a research associate and his influence as a professional reference helped with every subsequent step in my career, up to and including my current position. We've collaborated on various projects broadly involving fish metabolism, behavior, commercial fisheries, aquaculture, primary production, and cormorants. Based on associations with nearly every other person in this session, I can attest to the productive synergy generated from cross-pollination and working relationships among Jim's protégés, illustrating how his positive influences have multiplied across the realm of fisheries science in Michigan, the Great Lakes, and around the globe. Anyone acquainted with Jim knows he's scary smart, with a huge capacity to absorb, analyze, and synthesize all kinds of data and information, whether related to fisheries or any other social, political, or cultural topic. Besides being generous in sharing these intellectual gifts, Jim is one of the most approachable, friendly, interesting, engaging, and fun people on the planet. However, there is one arena where Jim's superiority and dominance can be truly daunting - on the basketball court! *Keywords: Admiration, Gratitude, Respect.*

SCHOENFUSS, H.L.[1], THOMAS, L.M.[1], WANG, L.C.[1], JORGENSON, Z.G.[1], CHOY, S.J.[2], BANDA, J.A.[3], GEFELL, D.J.[4], ANNIS, M.L.[5], TUCKER, W.A.[6], ELLIOTT, S.M.[7], and BRIGHAM, M.E.[7], [1]St. Cloud State University, St. Cloud, MN, 56301, USA; [2]US Fish & Wildlife Service, Madison, WI, USA; [3]US Fish & Wildlife Service, Columbus, OH, USA; [4]US Fish & Wildlife Service, Syracuse, NY, USA; [5]US Fish & Wildlife Service, East Lansing, MI, USA; [6]US Fish & Wildlife Service, Bloomington, IN, USA; [7]US Geological Survey, Mounds View, MN, USA. **CECs in Great Lakes Tributaries Alter Reproductive Potential in Resident and Lab Exposed Fish.**

Analysis of 500 water samples collected by the Great Lakes Restoration Initiative at 54 tributary sites confirmed the ubiquitous presence of Contaminants of Emerging Concerns (CECs). Cluster analyses suggests that CEC occurrence can be attributed to dichotomous urban or agricultural land use. Urban watersheds contained estrogens, BPA, alkyphenols, pharmaceuticals and personal care products. Agriculturally watersheds contained herbicides, BPA and alkylphenols, but lacked pharmaceuticals. 3,000 resident and caged sunfish were collected from 27 sampling sites and analyzed for indicators of stress associated with CEC exposure. In the presence of high aqueous CEC concentrations, glucose spiked in sunfish plasma and liver cells exhibited toxic stress response. Canonical redundancy analyses revealed that concurrent with indicators of toxic stress, biomarkers of reproductive potential declined. To examine the population level consequences, fathead minnows were exposed for 3 generations to the empirically derived urban CEC mixture. Subtle effects include reduced growth and altered reproduction. Juveniles lagged behind their control conspecifics in performing vital behaviors. Together, these studies indicates that CECs may impact Great Lakes fish populations. *Keywords: Endocrine disruption, Contaminants of Emerging Concern, Fish, Pollutants.*

SCHOLZE, T.K.[1], TAYLOR, W.W.[1], ROSEMAN, E.F.[2], EVANS, M.A.[2], HAYES, D.B.[1], WILLIAMS, N.A.[2], STUMPF, R.P.[3], and VANDERGOOT, C.S.[4], [1]Michigan State University, East Lansing, MI, USA; [2]USGS Great Lakes Science Center, Ann Arbor, MI, USA; [3]NOAA, Silver Spring, MD, USA; [4]USGS Lake Erie Biological Station, Sandusky, OH, USA. **Impacts of Lake Erie Harmful Algal Blooms on Larval Fish Abundance and Walleye Year-Class Strength.**

We evaluated the impacts of increasingly frequent and severe harmful algal blooms (HABs) on the trophic dynamics of walleye (Sander vitreus), their primary forage fishes, and associated zooplankton prey in the western basin of Lake Erie. In 2015 and 2016 we determined the abundance of larval fishes, zooplankton, and HABs at 14 sites by sampling weekly from June through August with a 112um zooplankton net and 500um paired bongo net. We evaluated the impact of HABs on the year class strength of young-of-year (YOY) fishes in the western basin of Lake Erie from 1995-2015 using satellite-derived HAB images and YOY catch data from the western basin interagency bottom trawl survey. We found that HABs were associated with significantly higher zooplankton abundance and lower larval fish abundance. We determined the catch per unit effort of YOY walleye and their preferred prey fishes was highest in years when HABs were relatively mild (Cyanobacterial Index > 3). Spatio-temporal trends in HAB severity also influenced year class strength; in 2015 a strong year class of walleye were produced despite a severe HAB occurring farther offshore. Fishery managers need to account for the impacts HABs will have on Lake Erie trophic dynamics and fishery ecosystem productivity to assure sustainable fish harvest under changing limnological conditions. *Keywords: Microcystis, Fish, Food chains.*

SCOFIELD, A.E.[1], WATKINS, J.M.[1], RUDSTAM, L.G.[1], XU, W.[2], and COLLINGSWORTH, P.[3], [1]Cornell University, Ithaca, NY, 14850, USA; [2]University of Illinois at Urbana-Champaign, Champaign, IL, 61801, USA; [3]IL-IN Sea Grant, Chicago, IL, 60604, USA. **A cross-lake comparison of trends in deep chlorophyll layers from 1996 to 2016.**

Deep chlorophyll layers (DCLs) are common features in deep mesotrophic to oligotrophic lakes with a stratified water column, including the North American Great Lakes. Over the past several decades, oligotrophication of the Great Lakes system and growth of invasive *Dreissena* mussel populations have led to greater water clarity and decreased epilimnetic chlorophyll concentrations across the lakes. Some of the observed losses in epilimnetic production may be offset by DCL formation, and a long-term perspective of trends in the vertical structure of chlorophyll distribution is important to understanding ecosystem change. Redistribution of phytoplankton could have considerable bioenergetics implications for higher-trophic-level organisms including zooplankton and prey fish. Several studies have investigated DCL dynamics in individual lakes, especially in Lake Superior and Michigan, and more recently in Lake Ontario. However, most previous studies comparing lakes are based on data from a few years at best, and the variety of methods employed makes long-term comparisons based on multiple studies challenging. This study builds on prior work by investigating long-term patterns in DCL formation using data collected through the US Environmental Protection Agency's Great Lakes National Program Office (GLNPO) from 1996 through 2016. *Keywords: Monitoring, Deep chlorophyll layers, Productivity, Water quality.*

SCRIBNER, K.T.[1] and WILSON, C.[2], [1]Dept. Fisheries and Wildlife, Michigan State University, 480 Wilson Rd. 13 Natural Resources Building, Dept. Fisheries and Wildlife, East Lansing, MI, 48824, USA; [2]Aquatic Biodiversity and Conservation Unit, Ontario Ministry Of Natural Resources, 2140 East Bank Dr., Peterborough, ON, K9J 7B8, CANADA. **Anthology of genetic laboratory and analytical methods applied to Great Lakes aquatic research.**

For many decades, Great Lakes aquatic resource managers have wrestled with grave threats to the integrity of the Great Lakes and inland watershed habitats and resident species. Sound stewardship of these spatially and systematically expansive and increasingly impacted resources necessitates acquisition and application of scientific information on aspects of species' ecology and on species interactions with their environment, including responses to anthropogenic stressors. There has been a long history of applications of genetic data and ecological genetics theory to supply information to managers. In this presentation we provide an anthology of the markers and the technical and analytical approaches that have been used for Great Lakes aquatic species, stressing ecological and managerial applications. We will review methodological advances in genetic markers and powerful inferences that are possible with recent analytical techniques. Researchers and managers work in an age of "Big Data" that embraces the need for large sample sizes and larges suites of parameters, including genomics and quantitative genetic data. We highlight how demographic, environmental and genetics data are being used together to address complex ecological questions, using case studies associated with different species and different geographic contexts. *Keywords: Management, Conservation, Genetics.*

SCRIBNER, K.T.[1], TSEHAYE, I.[3], BRENDEN, T.O.[1], STOTT, W.[2], and BENCE, J.R.[1], [1]Dept. Fisheries and Wildlife, Michigan State University, 480 Wilson Rd. 13 Natural Resources Building, Dept. Fisheries and Wildlife, East Lansing, MI, 48824, USA; [2]Great Lakes Science Center, 1451 Green Rd, Ann Arbor, MI, 48105-2807, USA; [3]Wisconsin Department of Natural Resources, Madison, WI, USA. **Hatchery Strain Contributions to Emerging Wild Lake Trout Populations in Lake Huron.**

During the past decade, wild-born lake trout (Salvelinus namaycush) have recruited in many areas of Lake Huron, as evidenced by capture of unclipped lake trout in assessment and fishery catches. Stocking began in Lake Huron in 1973, and since 1990 large numbers have been stocked annually. A critical information need is improved understanding of strain-specific recruitment variation over space and time. Because wild fish are untagged, managers lack the ability to characterize strain-specific rates of recruitment. We used microsatellite loci, age data, and genetic stock identification methods to determine relative contributions of stocked lake trout strains and how these contributions varied over years, ages and geographic regions. We found that Seneca strain lake trout contributed substantially to wild lake trout in the two time periods evaluated (2002-2004 and 2010-2012) in US and Canadian waters of the basin. Estimated strain contributions were not consistent with expected proportions based directly on the numbers of each strain stocked annually or on those numbers adjusted for estimates of age-specific survival and movements. Connecting successful reproduction to strain type will enhance managers' understanding of adaptive mechanisms and contribute to the development of more effective rehabilitation strategies. *Keywords: Lake trout, Recruitment, Genetics, Lake Huron.*

SEELBACH, P.W., USGS Great Lakes Science Center, 1451 Green Rd, Ann Arbor, MI, 48105, USA. **Reflections from Jim Diana's first graduate student.**

Early in my graduate student days at the University of Michigan, my advisor retired and dumped me into the lap of the incoming, hot-shot, new faculty member from Calgary Alberta- Dr. Jim Diana. For some reason he accepted me as his first PhD student; thus the first enduring qualities of Jim that were apparent included: graciousness and courage. Jim has served as guide, example, mentor, and friend throughout the whole of my professional career. I will share experiences that highlight many of Jim's strong qualities that have helped build and strengthen the fabric of Great Lakes fisheries science and management in recent decades. *Keywords: Education, Fisheries, Fish management.*

SEILHEIMER, T.S.[1], BLISS, H.[2], and HOUSE, A.[3], [1]Wisconsin Sea Grant, Manitowoc, WI, USA; [2]Great Lakes Indian Fisheries and Wildlife Commision, Odanah, WU, USA; [3]Apostle Island Sport Fishermen's Assocation, Washburn, WI, USA. **Beware of Great Lakes ghost nets!.**

Plastic pollution in the Great Lakes can come in many forms, but ghost nets can be dangerous to boaters and anglers. Ghost nets are lost commercial or subsistence fishing nets, usually gill nets, that have been lost due to weather, ice, or fouling. These unmarked nets can then become hazards, especially to anglers using trolling gear. Wisconsin Sea Grant, the Apostle Islands Sport Fishermen's Association, Great Lakes Indian Fish and Wildlife Commission, and the NOAA Marine Debris Program have partnered in a campaign to raise awareness about ghost nets in the upper Great Lakes and to more efficiently remove them. The project introduces anglers and boaters to the risks associated with marked commercial nets and ghost nets. Best management practices help commercial, tribal, and subsistence fishers to avoid conditions where nets could be lost. Anyone encountering a ghost net is encouraged to report the net, so it can be quickly removed. Removal of current ghost nets and fewer future nets will make the upper Great Lakes a safer place for recreation and enjoyment. With the proper education, you will say "I ain't afraid of no ghost net." *Keywords: Ghost net, Marine debris, Fisheries.*

SEMCESEN, P.[1], WELLS, M.G.[1], DOKA, S.E.[2], TANG, R.[2], and MIDWOOD, J.D.[2], [1]University of Toronto Scarborough, 1265 military Trail, Toronto, ON, M1C1A4, CANADA; [2]Fisheries and Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6, CANADA; [3]Environment and Climate Change Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6, CANADA. **Frequent hypoxic upwelling events in Hamilton Harbour driven by wind forcing.**

Hamilton Harbour suffers from persistent anoxia below the thermocline. Wind driven upwelling events occur frequently, which have a profound impact fish survival in the littoral zone. Hence its important to understand the spatial and temporal variability of dissolved oxygen (DO) in the regions of the harbour where expensive habitat restoration projects are underway. To this end we used historical wind data, bathymetry, and high frequency measurements of thermal stratification were used to model thermocline deflection for 2011. Desirable fish like Cisco have very specific temperature and DO range requirements for suitable habitat and are likely to be very susceptible to sudden changes in temperature and DO. The spatial distribution of fish habitat suitability is consequently influenced by the frequency, magnitude, and duration of thermocline deflection events predicted by this model. Based on the high dependence of upwelling events on windspeed direction and duration, we expected upwelling events to occur most frequently in the southwest and northeast and have the largest magnitude predominantly in the north and northeast areas of Hamilton Harbour. Our expectations were supported by both observed results from a measuring station and our model which predicted nearly 100 complete upwelling events over the summer stratified period. *Keywords: Hamilton Harbour, Oxygen, Water currents.*

SHARMA, S.[1], MAGNUSON, J.[2], O'REILLY, C.[3], GRAY, D.K.[4], HAMPTON, S.[5], and READ, J.[6], [1]York University, Toronto, ON, CANADA; [2]University of Wisconsin-Madison, Madison, USA; [3]Illinois State University, Normal, IL, USA; [4]Wilfrid Laurier University, Waterloo, ON, CANADA; [5]Washington State University, Pullman, USA; [6]USGS, Middleton, WI, USA. **On thin ice: are lakes feeling the heat?**

Lake summer surface water temperatures are warming rapidly. Ice may be a key mediator of the worldwide changes in temperature. Shorter ice duration, earlier ice breakup, and later ice formation have been observed throughout the Northern Hemisphere over the last century. In particular, earlier ice break-up may have the strongest effects on lake warming. We found that summer surface water temperatures have increased at rates of 0.34°C per decade between 1985-2009, with ice-covered lakes warming twice as fast as the global average. Warming lakes may lead to a 20% increase in algal blooms. We are proposing a new collaboration and invite North American collaborators to test mechanisms and

biological impacts of lake warming. Our goals of the synthesis project are to: 1) To gain a better understanding of the mechanisms that drive lake warming by testing the hypothesis that decreasing winter severity (i.e., earlier ice break-up and shorter ice duration) is leading to higher summer surface temperatures in lakes; and 2) To explore the potential biological impacts of warming by testing how productivity and water clarity have changed as lakes have warmed. *Keywords: Climate change, Productivity, Ice.*

SHAW, E., URBAN, N.R., and PRIYADARSHINI, M., Michigan Technological University, 1440 Townsend Ave, Houghton, MI, 49931, USA. **Legacy Contamination at Areas of Concern.**

Polychlorinated biphenyls (PCBs) are the legacy contaminant in highest concentration in Great Lakes fish and also the most frequent contaminant found in Areas of Concern (AOC). In order to understand the interplay between the 22 U.S. AOC sites and their adjacent communities, we must understand the nuances of PCB contamination in fish caught at these near-shore areas, including bullhead and carp. Longer food webs result in greater biomagnification, but nearshore fish may be exposed to higher concentrations from localized contamination (i.e. sediments), which could influence the overall PCB burden. This study examines the spatial and temporal trends of PCB congeners in nearshore fish with the following objectives: 1) identify the sources of PCBs; 2) evaluate evidence for decreasing levels of contamination in response to remediation efforts. Sources are identified by spatial trends in concentration and by multi-variate statistical analysis of congener patterns in fish. Time series data are analyzed for trends in response to remediation. Future analysis will examine population demographics within the AOC sites and will allow us to quantify the risk associated with the consumption of PCB contaminated fish. Together, these insights have the potential to aid policy makers in more effectively prioritizing future remediation work. *Keywords: Biomagnification, PCBs.*

SHEN, C.[1], LIAO, Q.[1], and BOOTSMA, H.A.[2], [1]Department of Civil and Environmental Engineering, Uinversity of Wisconsin-Milwaukee, Milwaukee, WI, USA; [2]School of freshwater sciences, University of Wisconsin-Milwaukee, Milwaukee, WI, USA. **Regulation of plankton and nutrient dynamics by profundal quagga mussels in Lake Michigan: A one dim.**

Invasive dreissenid mussels have altered plankton abundance and nutrient cycling in the Great Lakes. In this study, a 1D hydrodynamic-biogeochemical coupled model is developed to investigate their effects at a mid-depth offshore site in Lake Michigan. Driven by the simulated vertical mixing, the biological model solves the transport and transformation of nutrients, plankton and detritus in the water column. The biological model predicts a notable decline of phytoplankton biomass and considerable increase of dissolved phosphorus (DP) in the entire water column at the end of spring. However, the reduction of phytoplankton and the increase of DP are limited to the bottom 20m in summer as a result of the strong stratification. Model results also show that mussels can maximize food delivery to the benthos, as the modeled benthic diffusive flux of particulate phosphorus exceeds the passive settling rate by 4.2 X on average. However, food delivery to benthic mussels is ultimately limited by the settling of phytoplankton from the epilimnion across the thermocline. Model simulation over a 10-month period indicates that profundal mussels have the potential to significantly change the distribution of energy and nutrients in the water column, even in a deep and stratified environment. *Keywords: Lake Michigan, Biogeochemistry, Dreissena.*

SHERMAN, R.K., Severn Sound Environmental Association, 67 Fourth Street, Midland, ON, L4R 3S9, CANADA. **Severn Sound RAP the friendly little monster.**

The Severn Sound Remedial Action Plan started out as a federal-provincial initiative and became a "friendly little monster" when the community of small urban centers and rural townships took their responsibility seriously and became fully committed to seeing the restoration of Severn Sound as a "toxic hot-spot" on the Great Lakes. Severn Sound is a complex of bays and inlets in south-eastern Georgian Bay. The AOC was listed in 1985 because of eutrophication and habitat loss. This paper will explore the changes in organizational structure supporting RAP development and implementation from an external federal provincial program to a local organization supported by a variety of partners. Key principles of funding the remedial actions and administration of the local Severn Sound Environmental Association will be highlighted. This transition led to successful implementation and ultimate delisting of the AOC in 2003. Following delisting creative local partnership agreements and financing were arranged to continued long-term implementation and to meet emerging environmental challenges. *Keywords: Georgian Bay, Funding, Remediation, Organizations.*

SHIMODA, Y. and ARHONDITSIS, G.B., University of Toronto Sarborough, 1265 Military Trail, Toronto, ON, M1C 1A4, CANADA. **Guiding delisting decisions in the Great Lakes area: A prognostic tool for forecasting HABs.**

The Bay of Quinte, Lake Ontario, has a long history of eutrophication problems, mainly manifested by frequent and spatially extensive algal blooms and predominance of toxic cyanobacteria. The objective of this study is to develop a prognostic tool that will offer early warning signals of cyanobacteria blooms and forecast exceedance frequency of cyanotoxins above water quality standards. We first used Structural Equation Model integrated with Bayesian inference techniques to elucidate the key early seasonal abiotic factors (temperature, precipitation, wind, tributary flow, phosphorus and nitrogen concentrations) that may drive summer cyanobacteria dynamics and toxin productions; and to quantify the potential risk of exceeding a Provincial Water Quality Standard (Microcystin<1.5 μg/L). The information gained from this exercise were then used to develop a mechanistic model that aims to reproduce the spatial and temporal variability of nutrients, plankton community dynamics, and invasive species (i.e., dreissenid mussels) abundance. This modeling study will benefit the restoration efforts by providing the ecological forecasts with more realistic uncertainty estimates of the variable in probabilistic manner, rigorous assessment of the potential effects of various alternative management practices and future scenario uncertainty. *Keywords: Bay of Quinte, Harmful algal blooms, Modeling.*

SHROVNAL, J.S. and STAHLHEBER, K.A., University of Wisconsin - Green Bay, 2420 Nicolet Dr., Green Bay, WI, 54313, USA. **Phosphorus uptake potential of native and invasive plants for use in rain gardens of the Great Lakes.**

Phosphorus (P) loading due to terrestrial runoff leads to seasonal periods of eutrophication in Green Bay, Lake Michigan, as algae growth is primarily limited by P (Schindler 1977). When P is readily available rapid algal growth can deplete dissolved oxygen to the point where water quality is severely degraded, harming aquatic organisms, including fish (Roy-Poirier 2010). The ability of rain gardens to capture nitrogen runoff has been well documented (Gilchrist 2014) but their impacts on counteracting P runoff have been less characterized, despite their potential uses in urban and suburban settings. Plant species differ in P requirements and uptake efficiency (Föhse et al 1988), so careful design and selection of the plant community may be an effective avenue for increasing P capture in rain gardens and reducing potential loading to freshwater communities. We are quantifying the P uptake potential of mesocosms containing different plant communities: a mix of native grasses and forbs and four monocultures (two wetland natives *Typha latifolia, Sorghastrum nutans* and two wetland invasives *Phragmites australis, Phalaris arundinacea*). Replicate mesocosms were established in the UWGB Greenhouse and given excess P. This spring, we will measure plant P content and use total biomass to determine uptake potential *Keywords: Phosphorus, Vegetation, Watersheds.*

SHUCHMAN, R.A.[1], BROOKS, C.N.[1], KERFOOT, W.C.[2], SAYERS, M.J.[1], and GREEN, S.[2], [1]Michigan Tech Research Institute, Michigan Technological University, 3600 Green Ct., Ste. 100, Ann Arbor, MI, 48105, USA; [2]Michigan Technological University, 1400 Townsend

Dr., Houghton, MI, 49931, USA. **Mapping Stamp Sand Erosion and Deposition in Keweenaw Bay with Hyperspectral Imagery and LiDAR Data.**

The legacy of copper mining in the Keweenaw Peninsula includes 22.7 million metric tons (MT) of processed mining ore known as stamps sands that were deposited near the village of Gay, MI in the early 20th century. Previous work by the Michigan Tech-led team using historical records and multispectral and LiDAR 2008 data, provided by the U.S. Army Corps of Engineers, showed that about 3 million MT remains in the original stamp sands pile, 12 million metric tons has been redeposited along 8 km of shoreline, 1 million MT has been used for road applications, and 10 million MT has moved into Grand Traverse Bay, covering the original lake bottom. These underwater stamps sands have begun encroaching onto Buffalo reef, a productive spawning area for whitefish and lake trout, as well as severally impacting benthic organisms. Analysis of 2009 depth-corrected aerial images showed that a nearby trough area is mostly filled with stamp sands and acts as a reservoir for material that threatens the reef. We employ new 2016 imagery from the Army Corps, coupled with in situ sampling, to evaluate the current rate of stamp sands migration and the degree of reef encroachment. Our aim is to determine the most effective dredging strategy to minimize future movement of stamp sands onto Buffalo Reef. *Keywords: Remote sensing, Mining, Sediments, Mitigation.*

SIDICK, C.L., HARRINGTON, H.F., and CALAPPI, T.J., U.S. Army Corps of Enginers, 477 Michigan Ave, Detroit, MI, 48226, USA. **Classifying Habitat Units in the St. Marys Rapids with Hydrodynamic Modeling.**

The St. Marys Rapids at the outlet of Lake Superior are an important spawning ground for a wide variety of fish species. However, potential monthly gate changes at the head of the rapids alter the flow condition over recently deposited eggs. These changes in flow patterns can either strand eggs previously submerged in suitable conditions or wash submerged eggs from interstitial spaces during a rapid increase in water velocity associated with a gate opening. Recently, the U.S. Army Corps of Engineers has undertaken data collection and hydraulic modeling to minimize negative consequences of gate operations. Useful spawning grounds are comprised of appropriate water depth, velocity and substrate which differ among species. Using high resolution - imagery, topo-bathymetric LIDAR and hydrodynamic modeling, the rapids are classified based on suitability for salmonids, sturgeon and white fish. The modeling identifies the appropriate gate combinations to minimize adverse changes to water velocity and depth, especially during critical spawning season. Areas in the rapids are quantified based on gate opening, depth, velocity and substrate composition *Keywords: Decision making, Hydrodynamics, St. Marys River.*

SIERSZEN, M.E.[1], SCHOEN, L.S.[2], HOFFMAN, J.C.[1], KOSIARA, J.M.[2], and UZARSKI, D.G.[2], [1]USEPA Mid-Continent Ecology Division, 6201 Congdon Blvd, Duluth, MN, 55804, USA; [2]Central Michigan Unviersity, BioScience Complex 2410, Mount Pleasant, MI, 48859, USA. **Support of coastal fishes by nearshore and coastal wetland habitats.**

Hydrologic linkages among Great Lakes nearshore and coastal wetlands free coastal fish to move among the habitats, which has led to a variety of habitat use patterns. Fine-scale microchemical analyses of yellow perch otoliths have revealed life-history categories that include permanent wetland residence, annual migrations between nearshore and wetlands, nearshore residence, and combinations thereof. Stable isotope analyses to determine nutritional support of coastal fishes from 12 wetland-nearshore habitat pairs revealed differences among species and among systems in multi-habitat use. Frequently, most nutrition detected over the time-scale of stable isotope analyses came from the habitat in which fish were captured; however, substantial (> 30%) support often came from the adjacent habitat. Within-species variability in stable isotope ratios can be linked to differences among individuals in multi-habitat foraging. We compare the information gained from otolith microchemistry and isotope analyses and some of the ways stable isotope ratios can be linked to life history patterns. *Keywords: Coastal ecosystems, Food chains, Stable isotopes.*

SILOW, E.A., KRASHCHUK, L.S., ONUCHIN, K.A., PISLEGINA, E.V., RUSANOVSKAYA, O.O., and SHIMARAEVA, S.V., Irkutsk State University, Institute of Biology, Lenin str., 3, Irkutsk, 664025, RUSSIA. **Temperature trends in Lake Baikal and ecosystem changes.**

Lake Baikal, one of the oldest lakes on earth, the deepest (1642 m), and the largest in volume (23,615 cubic km) of all of Earth's freshwater bodies. A large number of the species living in Lake Baikal are endemic. Since February 1945, scientists at the Institute of Biology of Irkutsk State University have sampled plankton at weekly intervals, year-round, through all seasons, except for brief periods in early winter and spring when the ice is too treacherous for sampling. Most sampling was performed at a single site near the southern end of the lake. Regular, weekly, year-round sample taking is done at the pelagic stationary station No. 1. It's located in Southern Baikal, across from the village Bolshy'e Koty (51°52'48" N, 105°05'02"E, 2.7 km from the shore, above a depth of 800 m). There are water temperature changes observed during this period: increase of surface temperature (0.24 per decade), increase of 50 m depth temperature (0.10 per decade), increase of 0-50 m layer weighted average temperature (0.13 per decade). These trends may be the reason of changes observed in plankton community of the lake: under-ice season decrease of number of large cell endemic algae, endemic and non-endemic rotifers, as well as summer-autumn increase of

number of small cell non-endemic algae, non-endemic rotifers and cladocers.
Keywords: Climate change, Plankton, Arctic.

SIMOLIUNAS, S., Great Lakes Water Protection Committee, 665 W. Warren Avenue, Detroit, MI, 48201, USA. **The Need to Eliminate Elemental Chlorine from Great Lakes Water Authority Facilities.**

Since National Cancer Institute's report in 1987 that elemental chlorine disinfection of drinking water leads to elevated bladder cancer levels, most communities switched to safer disinfection (uv, ozone, chlorine compounds). However, USEPA and MDEQ allowed elemental chlorine for disinfection. I raised the issue in 2004 at MDEQ Office of Administrative Hearings contesting NPDES Permit No. MI0022802 by showing elevated organochlorines in Detroit River. MDEQ insisted that there was no rule against elemental chlorine for disinfection. It is high time to change the disinfection process at GLWA facilities. The drinking water is compromised, when elemental chlorine disinfection is used. The discharged water is the largest contributor of organochlorines to Detroit River as documented in many scientific studies. *Keywords: Chemical analysis, Organochlorine compounds, Detroit River.*

SIMON, K.L.[1], VENIER, M.[2], GUO, J.[2], and BOWERMAN, W.W.[3], [1]Natural Resource Technolog, Inc., 2260 E. Saginaw Street, East Lansing, MI, 48823, USA; [2]Indiana University, 702 N. Walnut Grove Avenue, Bloomington, IN, 47405-2204, USA; [3]University of Maryland, Animal Science /Agricultural Engineering Bldg., College Park, MD, 20742-5825, USA. **Bald Eagles as Indicators of Historic and Emerging Contaminants in the Great Lakes.**

Flame retardants are a wide range of compounds manufactured to delay ignition and reduce flammability of commercial products. A recurring pattern has developed as industry replaces legacy flame retardants with alternatives. In this study, we measured both historic and emerging flame retardants in egg and plasma samples from bald eagle (*Haliaeetus leucocephalus*) nestlings in Michigan between 2000 and 2012. Bald eagles serve as ideal indicators due to their high trophic position, providing insight into tertiary-level exposure of contaminants transported to Great Lakes aquatic ecosystems. We detected 38 brominated diphenyl ethers (BDEs) and non-BDE brominated congeners in at least one of the 22 egg samples analyzed. We detected 42 BDE and non-BDE brominated congeners in at least one of the 24 plasma samples analyzed. Thirteen dechloranes, or halogenated norbornene derivatives of Mirex, were detected in egg samples, and 20 dechloranes were detected in plasma samples. Eleven organophospate ester compounds were detected in egg samples, and 15 in plasma samples. Initial analyses indicate a greater concentration of dechloranes in both

egg and plasma from breeding areas along the Great Lakes in comparison to inland areas. In addition, concentrations of BDEs are also greater in egg samples from Great Lakes breeding areas. *Keywords: Environmental contaminants, Bioindicators, PBDEs.*

SIMONSON, M.A.[1], MAYER, C.M.[1], QIAN, S.S.[1], AREND, K.K.[2], BOSSENBROEK, J.M.[1], and WEIMER, E.J.[3], [1]University of Toledo Lake Erie Center, Toledo, OH, USA; [2]Old Woman Creek NERR, Huron, OH, USA; [3]ODNR Division of Wildlife, Sandusky, OH, USA. **Modeling Nearshore Fish Community Responses to Shoreline Types in Lake Erie.**

Approximately 80% of fishes from the Laurentian Great Lakes use the nearshore zone in some way (e.g., feeding, spawning, or nursery area) for at least part of the year. Extensive shoreline alteration and development along Ohio's Lake Erie coast has reduced habitat complexity and changed ecological connections at the interface of land, water, and air. We hypothesized that shoreline features affect the nearshore fish community composition. To determine relationships between shoreline types and the nearshore fish community, habitat features such as terrestrial vegetation, shoreline armor structure and submerged aquatic vegetation were classified at 51 coastal sites in the western and central basins of Lake Erie where fish were sampled between 2011 and 2016. Changes in the predicted relative abundances of nearshore fish community groups was modeled based on shoreline classifications, which shows that there is a higher relative abundance of native species at unarmored, non-vegetated shoreline sites and a higher relative abundance of sensitive species at coastal sites with intermediate density submerged aquatic vegetation. Understanding the impacts of shoreline modification on nearshore fish community attributes is critical to employing best management practices and maintaining critical fish habitats. *Keywords: Coastal ecosystems, Nearshore fish community, Habitats, Shoreline habitat, Environmental effects.*

SINGH, S.[1], REAUME, M.[2], SETH, R.[3], and TABE, S.[4], [1]Golder Associates, Calgary, AB, CANADA; [2]Stantec Consulting, Windsor, ON, CANADA; [3]University of Windsor, Windsor, ON, CANADA; [4]Ontario Ministry of Environment and Climate Change, Toronto, ON, CANADA. **Advanced Treatment of Secondary Treated Municipal Wastewater in the Great Lakes Region.**

Many chemicals of emerging concern (CEC) present in municipal wastewater effluent have the potential to interact with biochemical pathways and processes and induce adverse effects in aquatic organisms at very low (ng/L) concentrations. The list includes several pharmaceuticals and personal care products. The most notable effects reported are on the endocrine system, with widespread intersex reported in fish all around the world including several reports in North America. Multiple studies were conducted at pilot-scale to examine the effect of ozone, ozone followed by biofiltration and biofiltration alone on transformation of CECs, disinfection and toxicity reduction at a Municipal Wastewater Treatment Plant (MWTP) located in Windsor, Ontario, Canada that discharges secondary treated wastewater into the Detroit River. An ozone dose of ~0.7 mg ozone/mg DOC was sufficient for >80% transformation of 21 out of 31 targeted and detected CECs, achieve disinfection target of < 200 MPN *E. coli*/100 mL, and 60% reduction in genotoxicity. Additional genotoxicity reduction were observed when secondary treated MWTP effluent was ozonated prior to biofiltration, with biological activated carbon (BAC) biofilter outperforming the one with sand. Some genotoxicity reduction was achieved with direct biofiltration with BAC but not with sand. *Keywords: Municipal wastewater, Toxic substances, Disinfection, Great Lakes basin, Endocrine disruption.*

SINHA, E.[1], MICHALAK, A.M.[2], and BALAJI, V.[3], [1]Department of Earth System Science, Stanford University, Stanford, CA, USA; [2]Department of Global Ecology, Carnegie Institution for Science, Stanford, CA, USA; [3]Cooperative Institute for Climate Science, Princeton University, Princeton, NJ, USA. **Precipitation Dominates Interannual Variability of Riverine Nitrogen Loading Across the CONUS.**

Excessive nitrogen loading in waterways leads to increased eutrophication and associated water quality impacts. An understanding of the regional and interannual variability in nitrogen loading and associated drivers is necessary for the design of effective management strategies. Here we present a parsimonious empirical model based on net anthropogenic nitrogen input, precipitation, and land use that explains 68% of the observed variability in annual total nitrogen flux (Q_{TN}) (76% of ln(Q_{TN})) across 242 catchment-years. Application of this model to all eight-digit hydrologic unit watersheds within the continental US, from 1987-2007, reveals high spatial and temporal variability in loading, with spatial variability primarily driven by nitrogen inputs, but with interannual variability and the occurrence of extremes dominated by precipitation at both watershed and large aggregated scales. We also find that changes in future precipitation patterns alone will result in a significant increase in Q_{TN} in the northeastern US, including the Great Lakes region, by the end of the century under the "business as usual" scenario. These results imply that long-term management strategies must account for the role of meteorological variability and the impact of future changes in precipitation patterns. *Keywords: Nutrients, Modeling, Climate change.*

SLAWECKI, T.A.D., LimnoTech, 501 Avis Drive, Ann Arbor, MI, 48108, USA. **Defining Big Data for the Great Lakes.**

Ongoing advances in the collection, management and analysis of data -- often labeled as "big data" -- provide new opportunities for effective resource management decision-making. This presentation will introduce a common characterization of big data (the 5 Vs):

- *Volume*. Observations and measurements of familiar environmental parameters can be taken more frequently and at more locations, increasing the number of records.
- *Variety*. New, different kinds of data -- measurements of new parameters, integration of social information, asset management data, and more -- are becoming available for inclusion and assessment.
- *Velocity*. Improved technology reduces latency (the elapsed time between measurement and availability for analysis) while sampling frequency increases, potentially supporting decision-making in near-real-time.
- *Veracity*. As more and different kinds of data are made available for decision support, characterization and understanding of accuracy and precision of the data collected and its uncertainty implications become important.
- *Value*. Big data's bottom line is the realization of tangible benefits in many spheres.This value comes from the application of analytical tools (analytics).

Examples will be provided of applications to resource management decisions.

SLAWECKI, T.A.D., LimnoTech, 501 Avis Drive, Ann Arbor, MI, 48108, USA. **Some Thoughts on Early Warning Systems and the Great Lakes.**

As a launching point for discussions, this presentation will briefly review the literature on environmental early warning systems to develop a common vocabulary and identify key considerations for development of such systems for the Great Lakes. These considerations will include spatial, temporal and process scales; the nature of transitions and tipping points and their associated early warning signals; and the complexities of coupled human-environment systems. The presentation will also reflect on existing international efforts, such as the United Nation Environment Programme's Division of Early Warning and Assessment, and their suitability as models for Great Lakes early warning systems. Encouragingly, consolidation of some of the necessary Great Lakes data is already taking places through mechanisms such as GEO-Great Lakes and GLWQA Annexes.

Keywords: Decision making, Early warning systems.

SLIFE, C.C. and PATERSON, G., State University of New York College of Environmental Science and Forestry, 1 Forestry Dr., Syracuse, NY, 13210, USA. **Life cycle durations among Finger Lakes mysid populations.**

The freshwater mysid shrimp *(Mysis diluviana)* is a glacial relict species native to many deep cold water North American lakes, including New York's Finger Lakes region. Despite the importance of mysids as a prey resource for multiple fish species and their role in structuring zooplankton communities, relatively little is known regarding the life cycle duration of mysid populations. In this study, mysid populations inhabiting Cayuga, Keuka, and Skaneateles lakes in New York's Finger Lakes region were sampled to evaluate potential differences in the species' life cycle duration among these ecosystems. Mysids were collected from the spring through fall of 2016 and size frequency histograms indicated one year life cycles for each population. However, a late season juvenile cohort was also observed for the Cayuga population during the fall. Growth rates were also variable among populations with Cayuga lake mysids exhibiting the fastest growth rate (0.054 mm/d) and Keuka mysids growing the slowest (0.041 mm/d) over the duration of the open water season. Mysid life cycle duration has been hypothesized to be negatively correlated to lake trophic status. However, these results suggest that despite inhabiting predominantly oligotrophic ecosystems, shorter life cycles predominate among these Finger Lakes mysid populations. *Keywords: Life history studies, Mysis diluviana, Zooplankton, Finger Lakes, Lake management.*

SLODYSKO, K.N. and BOYER, G.L., SUNY College of Environmental Science and Forestry, 1 Forestry Dr, Syracuse, NY, 13210, USA. **Microcystin in Fish Tissue: A Potential Risk to Consumers?**

Microcystins (MC), a class of cyclic heptapeptide toxins produced by cyanobacteria, present a variety of risk factors to consumers. While the risk of exposure to MC through drinking water is well characterized, less is known about fish consumption as an exposure pathway. The WHO has established a tolerable daily intake (TDI) for the public of 0.04 μg MC-LR per kilogram of body weight. It is unknown if fish from lakes with blooms would contain amounts of MCs that would exceed the 0.04 μg TDI if consumed. Lake Champlain has a documented history of cyanoblooms especially in embayments like Missisquoi Bay. Muscle and liver tissues were collected and tested for MCs from three Lake Champlain fish species. Different extraction methods and purification protocols were tested including solid phase extraction. All samples were analyzed using tandem mass spectroscopy (LC-MS/MS). Concentrations of MCs in fish were found to be highly variable. MC concentrations in relation to their human health implications will be discussed. *Keywords: Harmful algal blooms, Fish toxins, Environmental health.*

SMITH, J.P.[1], MASON, L.A.[2], QIAN, S.S.[3], and GRONEWOLD, A.D.[4], [1]CILER, G110 Dana Building 440 Church Street, Ann Arbor, MI, 48109-1041, USA; [2]University of Michigan, School of Natural Resources, 440 Church St., Ann Arbor, MI, 48109-1041, USA; [3]The University of Toledo, Department of Environmental Sciences, 2801 West Bancroft St., Toledo, OH, 43606-3390, USA; [4]NOAA Great Lakes Environmental Research Laboratory,

4840 S. State Rd., Ann Arbor, MI, 48108-9719, USA. **MCMC modelling with JAGS and applications in the Great Lakes.**

Markov Chain Monte Carlo (MCMC) methods have made realistic modeling possible and are widely used in areas such as genetics, ecology, biostatistics, economics. Software packages, such as Just Another Gibbs Sampler (JAGS), have made MCMC accessible to many scientists, engineers, and other professionals looking to utilize the method. This high-level talk discusses the theory, the JAGS package, and a few applications including analyzing the effects of climate change on Great Lakes ice cover and water budget modelling. *Keywords: Mathematical models, Statistics, Decision making, MCMC, Computer applications.*

SMITH, M.[1], STOTT, W.[1], GILE, S.[2], and COTTRILL, A.[2], [1]Great Lakes Science Center-USGS, 1451 Green Rd., Ann Arbor, MI, 48105, USA; [2]Upper Great Lakes Management Unit-OMNRF, 1450 Seventh Ave. East, Owen Sound, ON, N4K 2Z1, CANADA. **Spatial Distribution of Naturally Produced Lake Trout from the Canadian Waters of Lake Huron.**

Lake trout, *Salvelinus namaycush*, have been stocked into Lake Huron since the 1950s using more than 10 different hatchery strains. Broodstock for the stocking program was derived from sources originating from lakes Huron, Michigan, Superior, and outside the Great Lakes. It is important for managers to understand the relative contribution rates of these strains to help determine which strains should continue to be used for rehabilitation. Microsatellite DNA markers can be used to determine the origins of wild-caught adult lake trout. We used genetic data, capture site information, age data, and historical stocking data to examine spatial and temporal changes in the contributions of different hatchery strains to resurging lake trout populations. Using Bayesian analysis software, we developed genetic profiles for Lake Huron's stocked hatchery strains and assigned wild-caught individuals to their likely strain of origin. The strain assignments were combined with stocking rates and age data to examine how the contributions of different hatchery strains have changed over time. Strains sourced from within Lake Huron (Lake Manitou) and from Seneca Lake accounted for most of the natural reproduction. The spatial distribution of the Lake Manitou and Seneca Lake strains differed and has changed over time. *Keywords: Lake trout, Stocking, Genetic stock identification.*

SMITH, Z.J. and BOYER, G.L., State University of New York College of Environmental Science and Forestry, 1 Forestry Drive, Syracuse, NY, 13210, USA. **Monitoring for Paralytic Shellfish Toxins in the Great Lakes: Challenges and Improvements.**

Historically, the class of cyanotoxins called the Paralytic Shellfish Toxins (PSTs) received most attention in marine environments. Due to recent detection of PSTs in US freshwater, it has become important to better understand PST prevalence in inland waters. For this reason, cyanotoxin monitoring in Lake Erie has begun to include Paralytic Shellfish Toxins (PSTs). Several analytical methods for PSTs are viable for monitoring programs including (1) chemical oxidation with HPLC and detection by fluorescence, (2) HPLC with mass-spectrometric detection (MS), and (3) PST ELISA. Samples from a New York State lake monitoring program covering 100 lakes were analyzed for PSTs using an HPLC-Fluorescence system. From the larger group samples a subset were then subsequently analyzed by MS and ELISA. The effectiveness and viability for the use of one of, or a combination of, the three methods for freshwater PST monitoring programs will be presented. *Keywords: Harmful algal blooms, Paralytic Shellfish Toxins, Environmental contaminants.*

SMUDDE, J.R., NEW Water, 2231 N. Quincy Street, Green Bay, WI, 54302, USA. **A Utility Led Agricultural Based Adaptive Management Pilot Study in Silver Creek - Green Bay, WI.**

Silver Creek is in a subwatershed of Duck Creek, located one mile west of Green Bay, WI, where a suite of best management practices (BMPs) are addressing high levels of nutrient and sediment runoff. The Green Bay Metropolitan Sewerage District, now NEW Water, is leading the project to evaluate if it is more cost effective to spend over $200 million on wastewater treatment plant phosphorus improvements or to work with agriculture to reduce phosphorus delivery to Green Bay. NEW Water is partnering with the local community to effectively execute an agricultural based Adaptive Management pilot project in the Green Bay area. Baseline data and inventory of the watershed has been completed and enhanced nutrient management plans and conservation plans have been developed. The first year of BMP implementation has been completed to reduce phosphorus and total suspended solids in Silver Creek, and water quality results have been gathered. The pilot study is utilizing innovative tools to execute field-level assessments, gather soil and water data, work closely with landowners and growers, and leverage local agronomist experience, to target the most effective practices. The pilot will review potential frameworks for implementing a future full scale Adaptive Management program to achieve continued permit compliance for NEW Water. *Keywords: Green Bay, Nutrients, Watersheds.*

SNYDER, B.D.[1], STAHL, L.L.[2], MCCARTY, H.B.[3], MURPHY, E.W.[4], and COHEN, T.R.[1], [1]Tetra Tech, Inc., Center for Ecological Sciences, 10711 Red Run Boulevard, Suite 105, Owings Mills, MD, 21117, USA; [2]U.S. Environmental Protection Agency, OW/Office of Science and Technology, 1200 Pennsylvania Avenue, NW (MC 4305T), Washington, DC, 20460, USA; [3]CSRA, 6361 Walker Lane, Suite 300, Alexandria, VA, 22310, USA; [4]U.S. Environmental Protection Agency, Great Lakes National Program Office, 77 West Jackson

Boulevard (MC G-17J, Chicago, IL, 60604, USA. **A New Approach for Assessing Mercury and PCBs in Great Lakes Fish.**

In 2010, the US Environmental Protection Agency (EPA) introduced a new approach for assessing chemicals in Great Lakes fish using a probability-based survey. This survey generated the first statistically representative data on the occurrence of mercury and PCBs in fillet tissue. EPA repeated the survey in 2015 to evaluate temporal trends. Fish were collected from 157 and 152 randomly selected US nearshore sites throughout the Great Lakes in 2010 and 2015, respectively. Fillet samples were analyzed for total mercury and all 209 PCB congeners. All samples contained detectable levels of mercury and PCBs, with maximum mercury concentrations of 956 and 557 ng/g in the respective studies. Total PCB maximums were 2,380 ng/g in 2010 and 1,168 ng/g in 2015. Probability distributions from 2010 showed that fillets in 11% of the sampled population (representing 11,091 sq km of nearshore area) exceeded EPA's 300 ng/g methylmercury fish tissue criterion. Using Great Lakes Sport Fish Advisory Task Force (SFATF) consumption limits, 60% exceeded the 110 ng/g (1 meal/week) threshold. Most of the sampled population had total PCB concentrations above 1 meal/week limits, including 99% above EPA's 12 ng/g human health (HH) cancer risk-based limit, 88% exceeding EPA's 47 ng/g noncancer HH limit, and 82% exceeding the SFATF 60 ng/g threshold. *Keywords: Fish, Mercury, Human health, PCBs.*

SNYDER, M.R.[1] and STEPIEN, C.A.[2], [1]University of Toledo & NOAA PMEL, Dept. Env. Sci, W. Bancroft St., Toledo, OH, 43606, USA; [2]NOAA PMEL, 7600 Sand Point Way NE, Seattle, WA, 98115, USA. **High-Throughput eDNA Assay to Assess Invasive Goby Species and Population Genetic Diversity.**

Identifying introduced species before they become established is critical, since early detection makes eradication more feasible and control more effective. Traditional sampling methods (nets, traps, electrofishing) are prone to false negatives and require taxonomic expertise. Environmental (e)DNA assays have been shown to be more effective at identifying rare species in aquatic environments. Ponto-Caspian gobies frequently establish outside their native range, including two taxa in the Laurentian Great Lakes: the round *Neogobius melanostomus* and tubenose *Proterorhinus semilunaris* gobies. We designed and tested an eDNA assay with high throughput sequencing of mtDNA cyt b variants that discerned among these and 5 other potentially invasive gobies, including the 3 most common Great Lakes round goby haplotypes. The assay was verified with mock communities containing known target sequence copy numbers and aquarium experiments containing comprising round and tubenose gobies of known numbers and haplotypes. Results indicate strong relationships between observed proportions of species/haplotype specific reads and those expected. This assay comprises an important new management tool for simultaneous

detection of multiple invasive species, including taxon identity, relative abundance, and population genetic variability. *Keywords: Genetics, EDNA, Invasive species, Management, Round goby, High-throughput squencing.*

SORICHETTI, R.J.[1], SHARMA, S.[1], PATERSON, A.M.[2], RUSAK, J.A.[2], YAO, H.[2], VAN ZUIDEN, T.[1], PALMER, M.E.[2], and HIGGINS, S.N.[3], [1]York University, Toronto, ON, CANADA; [2]Ontario Ministry of the Environment and Climate Change, Dorset and Toronto, ON, CANADA; [3]IISD Experimental Lakes Area, Winnipeg, MB, CANADA. **Time-Frequency Analysis Reveals Physical, Chemical, and Climate Drivers of Changing Algal Dynamics.**

Changes in algal dynamics have been observed over the past few decades on a global scale. Emerging bloom reports pertain to oligo-mesotrophic lakes and blooms are persisting later into the ice-free season (e.g., late November) compared to previous years. We utilized physico-chemical and algal biomonitoring data from 14 lakes in the Dorset Region (1981-present) and Experimental Lakes Area (1969-present) in Ontario to identify drivers of changing algal dynamics. Temporal synchrony analysis revealed that all algal groups changed coherently among lakes within regions, with the exceptions of cyanobacteria in Dorset and chlorophytes in ELA, pointing to potential regional drivers of change. Time-frequency analysis using Moran's eigenvector maps identified oscillations in algal biomass, while redundancy analysis described 29% of algal variation in Dorset and 39% in ELA. Despite observed synchrony, variance partitioning revealed that climate independently accounted for only 10% of variation explained in both regions, while physics (~15%) and chemistry (~30%) were higher. This study provides insight into the complex array of physical, chemical, and climate factors responsible for changing algal dynamics in Ontario lakes. Future research is needed to decouple climate signals that are propagated in physical and chemical lake processes. *Keywords: Climate change, Inland lakes, Algae, Lake chemistry, Modeling, Lake physical structure.*

SOULIGNAC, F.[1], ANNEVILLE, O.[1], TREVISAN, D.[1], BOUFFARD, D.[2], CHANUDET, V.[3], DAMBRINE, E.[1], GUENAND, Y.[4], HARMEL, T.[5], IBELINGS, B.[6], KIEFER, I.[2], UITTENBOGAARD, R.[7], and DANIS, P.A.[8], [1]INRA UMR CARRTEL, Thonon-les-Bains, FRANCE; [2]EPFL, Lausanne, SWITZERLAND; [3]EDF CIH, Le Bourget-du-lac, FRANCE; [4]Segula Technologies, Poisy, FRANCE; [5]LOV, Villefranche-sur-mer, FRANCE; [6]UNIGE, Geneva, SWITZERLAND; [7]Deltares, Delft, NETHERLANDS; [8]ONEMA, Aix-en-Provence, FRANCE. **Assessing water quality of lakes: should lake monitoring consider spatio-temporal variability?**

The European Parliament set out the European Water Framework Directive for managing and protecting water bodies. In France, lake ecological status is established by calculating biological and physico-chemical indicators based on data collected 4 times per year at a single site, located above the deepest point of the lake. Given the time and spatial variations of the parameters used in the water quality assessment, we question the representativeness of a few measurements at a unique sampling location for assessing Lake Geneva ecological status. Using a long term bi-monthly monitoring dataset, we evaluated the time dependence of 5 indicators following the standard procedure of the 4 sampling dates. A 3D ecological model was then used to analyse the spatial heterogeneity of the same indicators and the representativeness of the unique sampling location. This model was validated with the previous dataset and a satellite image survey. Results show that the choice of the sampling dates induces significant variability in the assessment of the ecological status for some parameters. Chla concentration, total phosphorus and transparency spatial variations indicate that 3D modelling can improve the assessment of water quality. Nevertheless, in terms of ecological status, the historical monitoring site appears reasonably representative. *Keywords: Water quality, Ecosystem modeling, Indicators.*

SOWA, S.P.[1], HERBERT, M.[1], ANNIS, G.[1], BRENNAN, A.[2], DELL, R.[1], DORAN, P.J.[1], FALES, M.K.[1], FROEHLICH, A.[2], PEARSALL, D.[1], ROSS, J.[1], SASSON, A.[2], STANLEY, W.[2], ASHER, J.A.[3], O'NEILL, G.[3], KEITZER, C.[4], LUDSIN, S.A.[4], and REWA, C.[5], [1]The Nature Conservancy, Lansing, MI, USA; [2]The Nature Conservancy, Dublin, OH, USA; [3]Michigan State University, East Lansing, MI, USA; [4]Ohio State University, Columbus, OH, USA; [5]Natural Resource Conservation Service, Beltsville, MD, USA. **Complementary Role of Science, Models, and Decision Tools in Helping Achieve Sustainable Agriculture.**

Over the past decade The Nature Conservancy has worked with many partners to build a foundation of science, models and decision tools to support adaptive management strategies that lead to sustainable management of agricultural lands in the Great Lakes. The objectives for this large body of work are to help us and our partners; 1) set realistic sustainability goals, 2) select the right conservation practices, 3) target practices to the right places, 4) support new ways of delivering and incentivizing practices, and 5) track progress toward goals. This presentation will briefly cover the methods, development, and evolution of the science, models and decision tools that have been developed for the Saginaw Bay watershed and Western Lake Erie Basin. This presentation will then provide case studies to demonstrate the complementary nature of this body of science, models and decision tools and how they collectively help us and our partners achieve all five of the above objectives within the Saginaw Bay watershed. *Keywords: Ecosystem modeling, Agriculture, Spatial analysis, Adaptive management, Water quality, Sustainability.*

SPENCE, C.[1], HEDSTROM, N.[1], GABRIELE, J.[1], and BLANKEN, P.D.[2], [1]Environment and Climate Change Canada, Saskatoon, SK, CANADA; [2]University of Colorado, Boulder, USA. **Ship-Borne Observations of Great Lakes Evaporation.**

Evaporation is significant to the water budget of the Laurentian Great Lakes, with commensurate influence on lake levels. Direct evaporation measurements are spatially limited. To address this gap, eddy covariance equipment was deployed on the CCGS Limnos in 2016. This presentation will summarize project planning, installation, operation, data retrieval, post-processing and quality control. Observations were made on four Great Lakes, providing a spatially diverse dataset of observed turbulent fluxes of these water bodies. This is part of the Great Lakes Evaporation Network, and these measurements augment existing observations from fixed sites on lighthouses. Comparisons between ship-borne estimates and those from a lighthouse installation at Long Point on Lake Erie during concurrent periods when flux footprints overlapped demonstrate the comparability of observations and feasibility of using ships as evaporation observation network platforms. These results provide confidence in the viability of future deployments on commercial vessels. As these systems also produce meteorological and lake surface temperature observations, there are large volumes of data and management within the context of their use for testing and improvement of numerical weather and algal bloom prediction models will be discussed.
Keywords: Climatic data, Atmosphere-lake interaction, Water level.

SPENCER, E.T., Ocean Conservancy, Washington, DC, USA. **Digital Media as a Tool to Inspire Participation in Invasive Species Management.**

Science communication had emerged not only as a way to disseminate information to a larger audience, but also as a way to provide tangible tools to engage people in conservation. Digital outreach is particularly applicable to the field of invasive species management, where anyone--regardless of scientific background, previous knowledge, or geographic location--can apply lessons learned to their own communities. Outreach content can include topics such as how to define and identify invasive species, how to prevent introductions, and how to participate in removals. The use of digital channels such as Twitter, Facebook, Snapchat, and YouTube bring resources directly into the hands of followers, and allow them to ask questions and interact with scientists (ex: Tweeting a photo of unknown plant species for identification, or following a video of how to fillet a lionfish for consumption). Since 2013, I have cultivated an online resource called the Invasive Species Initiative aimed at highlighting innovative responses to invasive species and providing resources to citizens who want to take action in their own backyards. Through case studies from the ISI, I will explore how social media can be used as a tool to inspire,

organize, and implement community-based invasive species management. *Keywords: Invasive species, Science communication, Environmental education.*

SPENCER, K.L.[1], BOEHLER, J.A.[2], LABRY, B.[1], GLOR, E.[1], RODGERS, E.[1], THOMPSON, A.[1], and KRIEGER, K.A.[2], [1]Heidelberg University Department of Biological and Environmental Sciences, 310 E. Market St., Tiffin, OH, 44883, USA; [2]National Center for Water Quality Research, 310 E. Market St., Tiffin, OH, 44883, USA. **DNA Barcoding for Identifying Sphaeriid Clams in the Laurentian Great Lakes.**

Tiny clams in the family Sphaeriidae are common in the bottom mud of lakes, wetlands and streams and supplement the diets of numerous fish species, yet their ecological role is not well studied. The few available taxonomic keys for identification of sphaeriids are outdated, ambiguous, and inoperative when identifying immature individuals that often comprise collections. DNA sequencing may help overcome these limitations. The purpose of this study was to investigate gene sequencing as a reliable method of identification for determining the distribution and abundance of native and exotic sphaeriid clams in the Laurentian Great Lakes. Individual clams were morphologically identified and sequenced for the 16S, 18S, and 28S rRNA genes. We considered the identifications to be: 1) a "match" if the sample was identified as the same species by both methods, 2) a "partial match" if there were multiple possibilities for either method, and there was overlap between the two, or 3) a "non-match" if the results were discordant. Of the 129 samples identified, there were 36 matches, 77 partial matches, and 16 non-matches. Further refinement of gene sequencing technology is needed to provide unambiguous identifications of the sphaeriid species known in the Great Lakes and those suspected of colonization. *Keywords: Great Lakes basin, DNA barcoding, Sphaeriidae, Taxonomy.*

ST. PIERRE, J.I.[1], CIBOROWKSI, J.J.H.[1], BROWN, T.N.[2], BRADY, V.J.[2], DANZ, N.[3], GATHMAN, J.P.[4], KOVALENKO, K.E.[2], HOST, G.[2], NIEMI, G.[2], and JOHNSON, L.B.[2], [1]University of Windsor, 401 Sunset Ave, Windsor, ON, N9B 3P4, CANADA; [2]Natural Resources Research Institute, 5013 Trunk Miller Highway, Duluth, MN, 55811, USA; [3]University of Wisconsin- Green Bay, 2420 Nicolet Drive, Green Bay, WI, 54311, USA; [4]University of Wisconsin- River Falls, 410 S. 3rd Street, River Falls, WI, 54022, USA. **A Multivariate Zoobenthic Assemblage Condition Index (ZACI) for Great Lakes Coastal Wetlands.**

We used sweep sample data collected at 144 wetlands across the Great Lakes as part of the Great Lakes Environmental Indicators project to quantify macroinvertebrate community condition. The Reference-Degraded Continuum (RDC) approach was used to derive composite Zoobenthic Assemblage Condition Indices (ZACI) for northern and

southern regions, related to human land use- agriculture and urban development via surrogate environmental gradients. Cluster analysis identified 5 reference assemblages of invertebrates based on relative abundance. Their locations could be distinguished by environmental features (hydrogeomorphology and aquatic habitat types). We used a two end-point Bray-Curtis ordination to delineate the extremes of the reference and degraded conditions, i.e. (reference-degraded continuum) and assessed the position of test sites along the continuum based on biota. ZACI condition scores showed distinct but varying trends among the five groups as a function of land-use stress. Important indicator taxa contributing to high ("reference") ZACI scores among groups included Chironomidae, Oligochaeta, Hydrobiidae and Hyalella; taxa characteristic of sites with low ("degraded") scores included Gammarus, Oligochaeta, Chironomidae and Hydrobiidae. *Keywords: Bioindicators, Coastal wetlands, Macroinvertebrates.*

STAHL, L.L.[1], MURPHY, E.W.[2], SNYDER, B.D.[3], MCCARTY, H.B.[4], and COHEN, T.R.[5], [1]U.S. Environmental Protection Agency, OW/Office of Science and Technology, 1200 Pennsylvania Avenue, NW (MC 4305T), Washington, DC, 20460, USA; [2]U.S. Environmental Protection Agency, Great Lakes National Program Office, 77 West Jackson Boulevard (MC G-17J), Chicago, IL, 60604, USA; [3]Tetra Tech, Inc., Center for Ecological Sciences, 10711 Red Run Boulevard, Suite 105, Owings Mills, MD, 21117, USA; [4]Computer Sciences Government Solutions, LLC, a CSRA company, 6361 Walker Lane, Alexandria, VA, 22310, USA; [5]Tetra Tech, Inc., Center for Ecological Sciences, 10711 Red Run Boulevard, Suite 105, Owings Mills, MD, 21117, USA. **Probability-Based Assessments of Perfluorinated Compounds in Great Lakes Fish.**

Perfluorinated compounds (PFCs) are persistent, bioaccumulative chemicals that are broadly distributed in the environment. In response to increasing concerns about health impacts of PFCs, the U.S. Environmental Protection Agency (EPA) conducted studies of PFCs in Great Lakes fish using unequal probability designs developed for the Agency's 2010 and 2015 National Coastal Condition Assessments. Fish samples were collected from 157 and 152 randomly selected U.S. nearshore locations throughout the Great Lakes in 2010 and 2015, respectively. Fillet tissue samples were analyzed for 13 PFCs. Results of both studies showed that PFOS dominated in frequency of occurrence. Maximum PFOS concentrations were 80 ng/g and 64 ng/g in the respective studies. The probability design allowed development of cumulative distribution functions (CDFs) to quantify PFOS concentrations versus the sampled population. Application of fish consumption advisory guidance to the CDFs resulted in estimates of the proportion of Great Lakes U.S. nearshore areas with fillet PFOS concentrations that exceed 2008 Minnesota Department of Health Fish Consumption Advisory Program limits and EPA human health protection thresholds based on the reference dose in EPA's Health Effects Support Document for PFOS published in May 2016. *Keywords: Fish, Perfluorooctane sulfonate, Human health.*

STAMMLER, K.L.[1], VELIZ, M.[2], LITTLE, C.[3], MERKLEY, C.[4], FLEISCHHAUER, S.E.[5], NAKHAIE, S.[1], DICK, M.[1], PRATT, A.[3], FUNK, M.[4], VAN DIETEN, B.[5], JACOBS, K.[7], and MCKAGUE, K.[6], [1]Essex Region Conservation Authority, Essex, ON, CANADA; [2]Ausable Bayfield CA, Exeter, ON, CANADA; [3]Lower Thames Valley CA, Chatham, ON, CANADA; [4]Upper Thames River CA, London, ON, CANADA; [5]Maitland Valley CA, Wroxeter, ON, CANADA; [6]Ontario Ministry of Agriculture, Food and Rural Affairs, Woodstock, ON, CANADA; [7]Ontario Soil and Crop Improvement Association, Guelph, ON, CANADA. **Many Hands Lighten the Load: Working Together to Reduce Phosphorus Loss from Agricultural Landscapes.**

The Great Lakes Agricultural Stewardship Priority Subwatershed Projects (PSP) began in the Fall of 2015 to address the question of the cost of reducing phosphorus loss from the agricultural landscape using a targeted stewardship approach. The PSPs are small agricultural watersheds (n = 6) that are representative of typical landscapes and land use practices throughout southwestern Ontario. This project is a collaboration between four Conservation Authorities, (ABCA, ERCA, LTVCA, MVCA and UTRCA), as well as the Ontario Ministry of the Agriculture and Rural Affairs, the Ontario Soil and Crop Improvement Association, academic researchers and the local farmers. All of the PSPs have been equipped to monitor ambient and event based stream water quality at or near the outlet of the PSP along with field scale monitoring at select sites within the PSPs. Each PSP also offers a unique cost-share program that allows farmers to implement BMPs such as cover crops and 4R nutrient management. A key component to this project is engagement of the farmers in each PSP, which has resulted in great success with uptake on the cost-share program. Water quality monitoring will be used to validate models that will help us better understand the effectiveness of agricultural BMPs to achieving the goal of 40% reduction in phosphorus to Lake Erie. *Keywords: BMP, Watersheds, Agriculture, Phosphorus, Lake Erie, Collaboration.*

STANTON, D.J., Saginaw Valley State University, 7400 Bay Road, University Center, MI, 48710, USA. **DNA Fingerprinting of Walleye (*Stizostedion vitreum*) from Saginaw Bay.**

There is a large population of walleye in Saginaw Bay that is both economically and ecologically important. The population is heavily managed and has been stocked extensively in recent years. In order to properly manage this population, genetic information is required. We obtained fin clips from walleye captured in Saginaw Bay for two summers by trolling.

With the help of the Department of Natural Resources (DNR), we also obtained fin clips from spawning populations using electroshocking on the Tittabawassee, Shiawassee, Kawkawlin and Rifle Rivers. In total, over 450 fin clips were obtained. DNA was extracted, using a DNeasy kit. PCR amplification and capillary electrophoresis were performed in order to determine genotypes for ten polymorphic DNA fingerprint loci. The data were analyzed by calculating the number of alleles per population, observed and expected heterozygosities, genetic distances (D) and population substructure (F_{ST}). Two private alleles were identified that were found in single spawning populations and in the bay population, which is indicative of spawning site fidelity. This information will aid management decisions regarding stocking programs, as well as decisions regarding damming of rivers and the construction of ladders to be used by spawning walleye. *Keywords: Fish, Genetics, Populations.*

STANTON, S.T.[1], HERBST, S.J.[2], KEIPER, W.D.[3], and HAYES, D.B.[1], [1]Michigan State University, East Lansing, MI, 48824, USA; [2]Michigan Department of Natural Resources, Lansing, MI, 48933, USA; [3]Michigan Department of Environmental Quality, Lansing, MI, 48906, USA. **Early Invasion Dynamics of New Zealand Mudsnails in Michigan Rivers.**

New Zealand mudsnails are a recent invader to the state of Michigan, and have generated considerable concern among resource managers. New Zealand mudsnails were initially detected in non-targeted surveys in the Pere Marquette River in 2015, and have since been found in the Au Sable and Boardman Rivers. Our first goal was to determine the spatial extent of this species in these rivers, and to determine how much the range has expanded in the Pere Marquette between 2015 and 2016 using targeted qualitative surveys. The 2015 surveys show that the distribution in the Pere Marquette River encompassed at least 9.8 river miles. Preliminary surveys indicate that the range has expanded in 2016, but results from fall sampling are still being summarized. In implementing these surveys, a natural question is how efficient are qualitative searches in detecting mudsnails when present. As such, our second goal was to estimate the detection probability for qualitative surveys. We implemented a split-plot type of sampling design, and found that when mudsnails were found in one sub-plot, they were also generally found in the other sub-plot, and rarely were there cases where they were found in only one sub-plot. Additionally, environmental DNA samples have been collected and are awaiting analysis. *Keywords: Invasive species, New Zealand mudsnails, Qualitative sampling.*

STAPLETON, M. and MIFSUD, D., Herpetological Resource and Management, P.O. Box 110, Chelsea, MI, 48818, USA. **A Case Study of Wildlife Response to Restoration of an Urban Landscape.**

In 2011, large scale efforts were initiated within a portion of the St. Clair River (an Area of Concern) in Port Huron, Michigan to restore 5,000 linear feet of shoreline and create new near-shore wetland communities. Measures were taken to provide improved habitat conditions for target wildlife taxa including herpetofauna, avifauna, and aquatic macroinvertebrates. Long-term monitoring of these groups revealed significant shifts in their presence and use of habitat within the project area. Data collected during our monitoring was valuable in demonstrating restoration progress and success. This presentation will highlight our results. *Keywords: Macroinvertebrates, Restoration, Reptiles, Bioindicators, Amphibians, Habitat Creation.*

STASTNA, M. and PENNEY, J., University of Waterloo, 200 University Ave West, Waterloo, ON, N2J 4G8, CANADA. **Gravity currents near the four degree temperature maximum.**

It is well known that freshwater has a density maximum around four degrees Centigrade. During and after ice off this implies that many riverine inputs into lakes may involve water for which mixing between the inflow and the ambient flow may lead to an increase in density. In the ocean this phenomenon is often referred to as "cabelling", though the oceanic situation is complicated by the dual dependence of density on salinity and temperature. We present three-dimensional direct numerical simulations of gravity currents in this situation. We demonstrate the manner in which the gravity currents lose material through the cabelling process, and quantify the expected length scale of penetration into the ambient fluid. In many cases, the gravity current continues to propagate along the domain bottom, energizing this environment and possibly mixing material across the bottom boundary layer. We will provide further context by contrasting our results with recent simulations of gravity currents involving both heat and salt. *Keywords: Hydrodynamic model, Bottom currents, Coastal ecosystems.*

STEINMAN, A., Grand Valley State University, 1 Campus Drive, Allendale, MI, 49401, USA. **Phosphorus and Benthos Response 11 Years After an Alum Treatment.**

Spring Lake, MI has a history of very high water column total phosphorus (TP) concentrations and summer cyanobacteria blooms. In 2005, Spring Lake was treated with alum to reduce internal P loading. In 2016, we measured sediment P release rates, water quality, and benthic macroinvertebrate community structure, and compared these findings with those from pre-alum (2004) and post-alum studies (2006 and 2010). TP concentrations in 2016 surface water were similar to those measured in 2006 and 2010 but TP concentrations in the near-bottom water at deeper sites were very elevated (250-1,000 μg/L) compared to 2006 and 2010. However, maximum P release rates from the 2016 sediments were modest (0.63 to 1.94 mg $P/m^2/d$), similar to or lower than 2010 rates, and still 10 times lower than pre-alum. The macroinvertebrate community continued its recovery from the decline that occurred shortly after alum application and was similar in density and composition to the 2010 results. These results suggest that internal P loading is increasing in magnitude in Spring Lake and illustrate that alum application is a short-term solution to the longer-term problem of internal P loading, and its effectiveness is critically tied to concurrent reductions in external P loading.

STEPIEN, C.A.[1], ELZ, A.E.[1], and SNYDER, M.R.[2], [1]NOAA PMEL, 7600 Sand Point Way NE, Seattle, WA, 98115, USA; [2]University of Toledo & NOAA PMEL, Dept. of Environmental Sciences, Toledo, OH, 43606, USA. **Population Genetic Characterization of the Silver Carp Invasion Front Approaching the Great Lakes.**

The silver carp *Hypophthalmichthys molitrix* was introduced from Asia to control algae in southern U.S. aquaculture. It escaped during the 1970s to become widespread throughout the Mississippi River basin, steadily moved northward, and now poses an imminent threat to the Great Lakes. This large, voracious and prolific filter-feeder is projected to severely impact food chains and threaten fisheries. Almost nothing is known of its fundamental population genetic variability, which we evaluated using nuclear DNA microsatellite variation and mtDNA sequences at the two most likely invasion entry sites (1) outside Chicago, Lake Michigan and (2) the Wabash River, leading to western Lake Erie through the Maumee River, in comparison to (3) the longer-established core population in the Mississippi River and (4) a later Missouri River colonization area. Microsatellite and mtDNA sequence data reveal considerable genetic diversity across the invasion, which may aid adaptation and success. Sequencing results reveal predominant haplotypes as well as unique (private) ones at each invasion front area. There are some significant divergences between the invasion fronts versus the core population. This research provides managers with important genetic baseline data and tools towards combatting the invasion and mitigating its effects. *Keywords: Carp, Silver carp, Genetics, Exotic invasion, Invasive species, Aquaculture.*

STETTNISCH, M.N.[1], BOCKWOLDT, K.A.[1], SALO, M.[1], SUCHOCKI, C.R.[1], NEUVILLE, K.P.[1], KLUMP, J.V.[1], KASTER, J.L.[1], GRUNDL, T.J.[1], and MAAS, M.[2], [1]University of Wisconsin - Milwaukee School of Freshwater Science, 600 E. Greenfield Avenue, Milwaukee, WI, 53201, USA; [2]COBACH, Bacalar, MEXICO. **Quantifying Benthic and Pelagic Primary Production in Laguna Bacalar.**

Laguna Bacalar, Mexico's second-largest lake, is a 42 km-long lake in the state of Quintana Roo. The municipal sewage infrastructure of the city of Bacalar appears inadequate to protect the Laguna against the recent surge in tourism. In 2016, scientists anecdotally noticed benthic algal mat growth around the Laguna's periphery. The algal mat appears to be growing in size, which may be the first sign that the Laguna is accelerating toward eutrophication. In January 2017, measurements of benthic and pelagic primary production in Laguna Bacalar were made using benthic chamber experiments, pelagic incubations, and nutrient experiments. All experiments were conducted within 2 km of the city of Bacalar where nutrient loading was expected to be greatest. Aerial drone imagery was also used to characterize the extent of the mat. Using both current drone imagery and historical satellite imagery, the change in algal growth over time was determined and used to calculate primary production in the benthic algal mat. The study results suggest that Laguna Bacalar is photosynthetically driven by high benthic primary production. *Keywords: Productivity, Phytoplankton, Benthos.*

STEWART, T.R.[1], VINSON, M.R.[2], and STOCKWELL, J.D.[1], [1]University of Vermont, 3 College St, Burlington, VT, 05401, USA; [2]U. S. Geological Survey, Great Lakes Science Center, Lake Superior Biological Station, 2800 Lake Shore Dr. East, Ashland, WI, 54806, USA. **Effect of photoperiod on cisco (Coregonus artedi) egg development.**

Cisco exhibit boom-or-bust population dynamics and may be particularly vulnerable to climate change. Cisco spawn in the fall and eggs develop over the winter with hatching occurring soon after ice-out. Water temperature and ice cover are changing in the Great Lakes and these factors influence the quantity and quality of light penetrating to the lake bed and thus may potentially impact the phenology and development rate of cisco eggs via photosensitive organs (e.g., retina and pineal organ). Developmental response of cisco eggs to changing winter light regimes may impact life history characteristics, and thus synchrony with spring algae and zooplankton blooms. We conducted a pilot lab experiment to test the effect of photoperiod on egg development and hatching of cisco at 2-3°C over the 2016-2017 winter. Fertilized eggs were exposed to three light treatments: continuous or seasonal diel photoperiod of high-intensity white (full-spectrum) light and continuous darkness. We hypothesized that exposure to continuous light accelerates development resulting in earlier hatching, larger larvae, and smaller yolk-sac area at hatch than eggs incubated under a diel light cycle or no light. *Keywords: Climate change, Cisco, Egg development.*

STOTT, W.[1], SMITH, M.[1], MACDOUGALL, T.[2], and ROSEMAN, E.[1], [1]Great Lakes Science Center-USGS, 1451 Green Rd., Ann Arbor, MI, 48105, USA; [2]Lake Erie Management Unit Ontario Ministry of Natural Resources and Forestry, Passmore Ave., Unit 7, Port Dover, ON, N0A 1N0, CANADA. **Historic and Contemporary Genetic Diversity of Lake Erie Cisco, *Coregonus artedi.***

Cisco, *Coregonus artedi*, was once found in all five Laurentian Great Lakes, but is now widespread in only Lake Superior with reduced populations in lakes Michigan, Huron, and Ontario and is considered extirpated from Lake Erie. However, fish identified as cisco are sometimes discovered larval assessment surveys on the Detroit River and in the bycatch of commercial gillnet and trawl fisheries in Lake Erie targeting yellow perch (*Perca flavescens*), white bass (*Morone chrysops*), rainbow smelt (*Osmerus mordax*), and lake whitefish (*C. clupeaformis*). Knowing the origins of these fish would help managers with plans for restoration of coregonids in the Great Lakes. We used molecular techniques to confirm the identity of these coregonids and compare their genetic profiles to those of contemporary adult cisco from Lake Huron and historical samples from Lake Erie. One sample was determined to be lake whitefish based on cytochrome oxidase I sequences. Significant differences were found among contemporary and historical samples from Lake Erie and Lake Huron allowing the contemporary Lake Erie cisco to be assigned to a specific lake of origin. *Keywords: Cisco, Historical genetic diversity, Individual assignment.*

STOUGH, J.M.A.[1], TANG, X.[2], KRAUSFELDT, L.E.[1], STEFFEN, M.M.[3], GAO, G.[2], BOYER, G.L.[4], and WILHELM, S.W.[1], [1]Department of Microbiology, The University of Tennessee, Knoxville, TN, 37996-0845, USA; [2]State Key Laboratory of Lake Science and Environment, Nanjing Institute of Geography & Limnology, Chinese Academy of Sciences, Nanjing 210008, PR, CHINA; [3]Department of Biology, James Madison University, Harrisonburg, VA, 22807, USA; [4]College of Environmental Science and Forestry, State University of New York, Syracuse, NY, USA. **Discrimination of temperate vs lytic phage activity in Microcystis blooms using systems biology.**

Phage play a fundamental role in harmful algal blooms by releasing nutrients from primary producers and heterotrophs and transferring genetic material between organisms, thus shaping biological diversity. Yet in spite of intense interest in the toxic bloom-forming cyanobacterium Microcystis aeruginosa, little is known about phage infecting these populations. Only two sequenced representatives have been studied, and both are thought to be closely-related lytic myoviruses. The Microcystis phage Ma-LMM01's genome, however, encodes machinery that might support lysogeny, including two transposases and a site-specific integrase. In analyzing RNA-seq data obtained from 2 years of Microcystis blooms in Lake Erie and Lake Tai (China), we have observed that these potentially lysogenic genes are highly expressed when genes involved in lytic infection are down-regulated ($\varrho = -0.44$, $p < 0.005$). This pattern is consistent, though not always statistically, across multiple spatial and temporally distinct samples. Expression of these two sets of genes appears to be linked to microcystin concentration, total dissolved nitrogen, and salinity. Our results suggest that lysogeny may be prevalent in Microcystis blooms, and lead us to hypothesize that abiotic factors drive switching between temperate and lytic life cycles. *Keywords: Lake Erie, Bacteriophage, Microcystis, Lysogeny, Trancriptomics.*

STOW, C.A.[1], ROWE, M.D.[2], RUBERG, S.A.[1], JOHENGEN, T.H.[2], ZHANG, H.[2], BELETSKY, D.[2], JOSHI, S.J.[2], COLLINGSWORTH, P.[3], MASON, D.M.[1], KRAUS, R.T.[4], and ANDERSON, E.J.[1], [1]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, USA; [2]University of Michigan, Ann Arbor, USA; [3]Purdue University, West Lafayette, USA; [4]US Geological Survey, Sandusky, USA. **Lake Erie Hypoxia Forecasting for Public Water Systems Decision Support.**

The potential risk to drinking water quality when water intakes in Western Lake Erie draw source water containing algal toxins is widely appreciated. However, the difficulties encountered when municipal intakes periodically draw hypoxic source water from the hypolimnion of Lake Erie's central basin remain largely unrecognized. This low-oxygen, low-pH water is usually discolored and may contain iron and manganese at concentrations requiring expensive treatment. This problem occurs in response to episodic meteorological events causing local water conditions to change over short time-scales. NOAA GLERL and the Cooperative Institute for Limnology and Ecosystems Research are developing an early warning system to alert managers when conditions make hypoxic water exposure likely. The project will build on existing observing system and hydrodynamic modeling capabilities and be guided by a committee of stakeholders, including drinking water intake managers, to ensure that forecasts are useful for effective decision-making. This presentation will offer a project overview and include a foreshadowing of future model applications, including a refinement of capabilities to project central basin hypoxia under future nutrient input and climate scenarios. *Keywords: Lake Erie, Drinking water, Lake model.*

STRANDBERG, U.[1], BHAVSAR, S.P.[2], and ARTS, M.T.[1], [1]Ryerson University, Toronto, ON, CANADA; [2]Ontario Ministry of the Environment and Climate Change, Toronto, ON, CANADA. **Correlation Between Fish Omega-3 Levels And Consumption Advisories.**

Most of consumption advisories assigned for Great Lakes fish are due to elevated concentrations of polychlorinated biphenyls (PCBs); highly lipophilic compounds. The highest PCB concentrations are detected in fatty salmonids. The high lipid content also makes salmonids a rich source of nutritionally important omega-3 fatty acids, eicosapentaenoic (EPA) and docosahexaenoic acids (DHA), for humans. The consumption advisory was negatively correlated with the EPA+DHA content in fish from Lakes Ontario and Huron mainly because salmonids, which had the highest EPA+DHA content, also had the most stringent consumption advisories. When the consumption advisories are followed, the stringent advice restricted the total intake of EPA+DHA. Thus, the EPA+DHA content alone does not necessarily provide the most accurate estimation of the importance of a particular fish species as a safe source of EPA+DHA. The negative correlation between the consumption advisory and the EPA+DHA content in fish, also indicates that decreasing contaminant level and less stringent consumption advisories would not only decrease the potential risk of consuming fish from Lake Ontario and Lake Huron, but at the same time increase the relative benefits, i.e. importance as a source of EPA+DHA. *Keywords: Fish, Lake Huron, Lake Ontario.*

STRATTON, L., FUTIA, M., and RINCHARD, J., The College at Brockport - SUNY, 350 New Campus Drive, Brockport, NY, 14420, USA. **Prevalence of thiamine deficiency in lake trout eggs from Cayuga Lake.**

Early mortality syndrome is a reproductive disorder affecting salmonid species from the Great Lakes region. It is characterized by a thiamine deficiency in eggs due to poor maternal transfer resulting in high offspring mortality from the yolk-sac stage to the swim-up stage. To determine the prevalence and severity of low thiamine concentration, we monitored thiamine concentration in lake trout eggs from Cayuga Lake from 2009 to 2016. Initially, lake trout egg concentration was above the recommended management objective of 4 nmol/g. From 2010 to 2014, eggs from most of the females were below the threshold and averaged a concentration of 1.9 nmol/g. An increase of thiamine concentration was observed in 2015 (9.0 ± 5.7 nmol/g) but large variations were observed among females. These results indicate that thiamine deficiency is prevalent in Cayuga Lake and is an impediment to lake trout natural reproduction. *Keywords: Lake trout, Finger lakes, Vitamin B.*

STUART, D.G.[1], BURTNER, A.M.[1], JOHENGEN, T.H.[1], MILLER, R.J.[1], PALLADINO, D.A.[1], and RUBERG, S.A.[2], [1]Cooperative Institute for Limnology and Ecosystems Research, 440 Church St, Ann Arbor, MI, 48108, USA; [2]NOAA - Great Lakes Environmental Research Laboratory, 4840 S State Rd, Ann Arbor, MI, 48108, USA. **Trends In Nitrate, Phosphate And Bloom Indicators During The 2016 Western Lake Erie Field Season.**

The factors contributing to harmful algal bloom (HAB) initiation and persistence are not well understood in western Lake Erie. The 2016 field season saw a continuation of the Cooperative Institute for Limnology and Ecosystems Research (CILER) and NOAA-GLERL joint weekly monitoring plus deployment of real-time, in-situ, continuous water quality data buoys from May to November. Buoys were equipped with instruments to measure dissolved phosphate and algae bloom indicators (chl a, phycocyanin) as well as other water quality parameters. New in 2016 was the addition of in-situ nitrate sensors at two of these buoys. Here we present the trends observed in buoy-based measurements as

well as lab results from weekly monitoring samples on small and season-long scales.
Keywords: Lake Erie, Harmful algal blooms, Buoys.

STURTEVANT, R.A.[1], BERGERON, D.[2], and BUNTING-HOWARTH, K.E.[3], [1]Great Lakes Sea Grant Network, 4840 South State Road, Ann Arbor, MI, 48108, USA; [2]MN Sea Grant, Duluth, MN, USA; [3]New York Sea Grant, Ithaca, NY, USA. **Stakeholder Engagement in a Wicked World:Crude Oil Transport in the Great Lakes Region.**

Crude oil travels through the Great Lakes Basin (GLB) in unprecedented quantities. Overall domestic crude production has increased 38% since 2009. Crude oil production has begun to outpace pipeline capacity putting increasing pressure on other forms of transportation, rail, truck and barge. Increased safety concerns related to these alternative transportation modes, aging and inadequate infrastructure compounds stress on the system. In addition, there are multiple potential threats to the environment and human health associated with an accident. Wicked problems are difficult to resolve because they are dynamic, involve complex interdependencies and include diverse stakeholders with contradictory requirements. Stakeholder engagement is key to addressing wicked problems so that divergent opinions and competing interests can be shared and explored, collaboratively. Concept mapping is a visual learning tool for organizing and representing knowledge. By visually structuring knowledge, concept maps allow users to examine relationships among larger numbers of ideas than can normally be held in working memory and facilitate use of knowledge in new contexts. This presentation will discuss the use of concept mapping to address the problem of crude oil transport in the GLB.
Keywords: Decision making, Regional analysis, Environmental policy.

STURTEVANT, R.A.[1], MARTINEZ, F.[2], RUTHERFORD, E.S.[3], ELGIN, A.K.[3], SMITH, J.P.[4], and ALSIP, P.[4], [1]Great Lakes Sea Grant Network, 4840 South State Road, Ann Arbor, MI, 48108, USA; [2]NOAA NCCOS, 4840 South State Road, Ann Arbor, MI, 48108, USA; [3]NOAA Great Lakes Environmental Research Laboratory, 4840 South State Road, Ann Arbor, MI, 48108, USA; [4]Cooperative Institute for Limnology and Ecosystems Research, 4840 South State Road, Ann Arbor, MI, 48108, USA; [5]NOAA GLERL, 1431 Beach St, Muskegon, MI, 49441, USA. **Update on the Great Lakes Aquatic Nonindigenous Species Information System (GLANSIS).**

The Great Lakes Aquatic Nonindigenous Species Information System (GLANSIS) is both a Great Lakes specific node of the USGS Nonindigenous Aquatic Species (NAS) database as well as a NOAA project to improve access to research-based information on established and potential nonindigenous species in the Great Lakes in support of research and management. Unrolled in 2003 and significantly upgraded (thanks to funding from the

Great Lakes Restoration Initiative - GLRI) in 2010, the database provides information on more than 180 established species and 67 watchlist species including information on identification, ecology, distribution, impact (or risk assessment), and management. In addition to the database, the program has recently published a series of Technical Memoranda compiling, documenting and analyzing the data in its holdings. GLANSIS is now entering another phase of change with an influx of new GLRI funding. In the coming year we anticipate adding enhanced search capacity, new risk assessment information, new watchlist species, serving GIS data layers, and looking at spread patterns within the basin.
Keywords: Invasive species, Data storage and retrieval, Biological invasions.

SU, Z.S., Institute for Fisheries Research, 400 N. Ingalls Room G250, Ann Arbor, MI, 48109, USA. **Bayesian Hierarchical Modeling A modern approach for fisheries modeling.**

Recreational fisheries are the major component of the Great Lakes fisheries. These fisheries are usually monitored through onsite angler surveys, which have provided total catch and fishing effort data essential for fisheries stock assessment and management. However, there are drawbacks in using site-specific direct survey estimators to make fisheries estimates for these surveys. The deficiencies of the direct survey estimation methods motivate us to develop a model-based approach to improve estimates for each individual site, as well as to impute missing data in the surveys and make predictions for future trends for these fisheries. For this purpose, we build Bayesian hierarchical dynamic models that explicitly take into account temporal dependent (time series) structure in the historical data for each site as well as spatial associations among sites. As a case study, we use the models to examine fishing effort dynamics of multiple fishing sites from Lake Michigan. However, such models can be applied to multiple time series data for a wide range of applications.
Keywords: Lake Michigan, Ecosystem modeling, Salmon.

SUCHOCKI, C.R.[1], BOCKWOLDT, K.A.[1], STETTNISCH, M.N.[1], NEUVILLE, K.P.[1], SALO, M.[1], MAAS, M.[2], and MCKENZIE, R.[3], [1]University of Wisconsin-Milwaukee School of Freshwater Sciences, 600 E Greenfield Ave, Milwaukee, WI, 53204, USA; [2]COBACH Bacalar, Bacalar, MEXICO; [3]US Forest Service, Hilo, USA. **A Widespread Algae Mat Growing in Laguna Bacalar, MX: A comparison of historic and recent condition.**

In 2007, SFS research began on Mexico's second largest freshwater lake, Laguna Bacalar, to understand the changes in the Laguna potentially impacting its living giant stromatolites, discovered by SFS scientists. Researchers have anecdotally noticed a benthic algae mat growth on the bottom of the Laguna around the Laguna's periphery. The mat appears to be growing in size and may be the first early warning sign that the Laguna is accelerating toward eutrophication. The most serious, immediate crisis is the size increase of the algae mat and its ecological disruption to the stromatolites and the resultant local/regional economic disruption as ecotourism in the area depends on viewing the stromatolites. Increasing spread of the algae mat and increased primary production measured as algae growth rate will likely stimulate the spread of a zebra mussel cousin (Mytilopsis) that will grow densely on the stromatolies, thus killing them. This is the principal conservation fear, that the stromatolites will vanish and the ecology collapses. Using arial footage attained via the usage of drone quadcopters, the size and area of the mat was calculated to serve as a baseline for future measurements which will be taken to aid in the determination of algae mat growth and change over time. *Keywords: Cameras, Drone, Algae.*

SUEDEL, B.C.[1], IMBRUNONE, J.T.[2], HARRINGTON, H.F.[2], and FRIONA, A.M.[3], [1]US Army Engineer Research and Development Center, 3909 Halls Ferry Road, Vicksburg, MS, 39180, USA; [2]US Army Corps of Engineers Detroit District, 477 Michigan Ave, Detroit, MI, USA; [3]US Army Corps of Engineers Buffalo District, 1776 Niagara Street, Buffalo, NY, USA. **How the Corps is Increasing Habitat Value on Great Lakes Coastal Structures.**

Through the US Army Corps of Engineers, Engineering With Nature program, along with support from the Great Lakes Restoration Initiative, demonstration projects are being implemented to determine whether minor modifications to breakwater structure repairs result in increased habitat quality for various aquatic species. These structures already provide some beneficial habitat for fisheries and waterfowl; however, this aspect is an unintentional attribute rather than integral to design. Our goal was to investigate opportunities to design or maintain the structures such that they provide increased sustainability such as enhancing fish habitat. This addition would provide low-cost measures that could be implemented as part of routine maintenance or repairs. The project in Milwaukee Harbor, WI was developed to broaden the environmental and social benefits that are provided by the breakwater that were easily integrated as part of ongoing maintenance by making simple, low cost modifications to the design of the stone used to repair the breakwater. Use of the site by fish and invertebrate forage species was monitored over 2.5 years. With consistent application of such simple modifications during structural repairs, there is tremendous potential to increase multiple benefits associated with built navigation infrastructure. *Keywords: Breakwaters, Rocky shore community, Coastal ecosystems, Habitat improvement, Fish, Restoration.*

SYMBAL, M.J.[1] and LEONARD, J.B.K.[2], [1]USFWS Sea Lamprey Control, 3090 Wright Street, Marquette, MI, 49855, USA; [2]Northern Michigan University, 1401 Presque Isle

Avenue, Marquette, MI, 49855, USA. **Lampricide induced growth and metabolic response of Age-0 Lake Sturgeon *Acipenser fulvescens*.**

The lampricide 3-trifluoromethyl-4-nitrophenol (TFM) can be lethal to juvenile lake sturgeon *(Acipenser fulvescens)* at high concentrations used to control invasive sea lamprey *(Petromyzon marinus)*; however, little is known about the effects of sub-lethal TFM exposure more typically encountered by sturgeon. This study documented TFM's effect on mortality, instantaneous growth and standard metabolic rate of Age 0 lake sturgeon. Juvenile lake sturgeon (n=252) progeny of a wild 1:1 cross of adults taken from Black Lake, MI, were exposed to three concentrations of TFM (0.0, 0.68, and 1.36 mg/L) for 12 hours and then reared in clean water. There was no mortality with these exposures. Instantaneous growth and standard metabolic rate were calculated for each fish two weeks post exposure. We found a 15.8% reduction in standard metabolic rate of sturgeon exposed to 1.36 mg/L compared to those placed in the 0.0 mg/L concentration (p=0.015). Instantaneous growth was not different between treatment groups (p=0.293). Our research demonstrates metabolic impairment of age-0 lake sturgeon caused by sub-lethal exposure to TFM. Future research is directed toward evaluating the duration of this impairment. *Keywords: Metabolism, Sturgeon, Invasive species, Lampricide, Pesticides.*

SYSLO, J.M.[1], JONES, M.L.[1], FLEISCHMAN, S.J.[2], and CATALANO, M.J.[3], [1]Quantitative Fisheries Center - Michigan State University, 375 Wilson Rd., Room 101, East Lansing, MI, 48824, USA; [2]Alaska Department of Fish and Game, 333 Raspberry Rd., Anchorage, AK, 99518, USA; [3]Auburn University, 217 Swingle Hall, Auburn, AL, 36849, USA. **Accounting for Escapement Quality in a Stock-Recruit Model for Yukon River Chinook Salmon.**

Chinook salmon spawning runs have declined throughout western Alaska during the past two decades. Declining escapement quality, ultimately leading to reduced egg deposition, has been hypothesized as one mechanism causing declining salmon returns. We developed a Bayesian state-space run reconstruction and stock-recruit model for Chinook salmon in the Canadian portion of the Yukon River from 1982 through 2015. We then compared results from a version of the model using total escapement as the predictor variable in a Ricker stock-recruit relationship to a version using fecundity of the escapement as the predictor variable. The two models produced similar estimates of annual run size, which declined from 1996 through 2013. The two models also produced similar descriptions of the stock-recruitment relationship; however, the model using fecundity of the escapement as the independent variable produced more precise estimates for the production parameter (α) and serial autocorrelation in productivity. Temporal variation in escapement quality did not explain the decline in run size. *Keywords: Salmon, State-space modeling, Recruitment, Mathematical models.*

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TAN, C.S. and ZHANG, T.Q., Research & Development Centre, AAFC, RR #2, 2585 County Road 20, Harrow, ON, N0R 1G0, CANADA. **Innovative drainage water management strategies to reduce nutrient loading.**

Algal blooms have increased in severity over the past two decades in the Great Lakes. An innovative drainage water management study was developed for mitigating nutrient loss and protecting the environment and ensuring food safety and quality. Studies were conducted on clay loam soils using large field plots equipped with automatic flow volume measurement and sampling systems over three separate 4-year periods (1995-1999; 2001-2005; 2008-2012) at three different sites to evaluate total nitrate and phosphorus losses under two drainage water management systems (regular free drainage, RFD, vs. drainage control/sub-irrigation, DCS) with a corn-soybean rotation. The results showed that averaged all three separate period DCS system reduced combined surface and sub-surface total nitrate loss by 41 % and total P loss by 12 % relative RFD system. For RFD system, of the total nitrate and phosphorus losses, about 9 % and 32 % were accounted for surface runoff water, while 91 % and 68 % were accounted for sub-surface tile drainage water, respectively. For DCS system, about 43 % and 73 % of the total nitrate and phosphorus losses were in surface runoff water, while 57% and 27 % were in sub-surface tile drainage water, respectively. DCS system can be considered a beneficial management practices to reduce total nitrate and soil P losses. *Keywords: Nutrients, Phosphorus, Water quality.*

TANG, R., REDDICK, D., MIDWOOD, J.D., and DOKA, S.E., Fisheries and Oceans Canada, 867 Lakeshore Rd., Burlington, ON, L7S1A1, CANADA. **Long-term dissolved oxygen and temperature monitoring in Great Lakes AOCs.**

Dissolved Oxygen (DO) and temperature are important components of fish habitat. Understanding the spatial dynamics of oxygen in water is fundamental to the distribution, behavior and growth of fishes in lakes. As part of the Great Lakes Action Plan (GLAP), Fisheries and Oceans Canada have been monitoring the DO and temperature trends in a number of designated Areas of Concern (AOC) across the Laurentian Great Lakes since 2007. Dissolved oxygen and temperature loggers were deployed on a semi-continuous basis across AOCs. The long-term dataset was used as a tool for both recommending water quality delisting target for Remedial Action Plans (RAP) and for suitable fish habitat modeling. We will be discussing the issues, challenges and productivity for the long-term monitoring database and their implications for fish habitat assessments and water quality. Hamilton Harbour and Cootes Paradise, Ontario will be used as a case study scenario for the discussion, which is characterized by its low DO levels due to eutrophication and basin

morphometry, resulting in the loss of fish habitat. *Keywords: Productivity, Areas of concern, Oxygen, Temperature.*

TAYLOR, J.[1] and STAMMLER, K.L.[2], [1]Ontario Greenhouse Vegetable Growers, 32 Seneca Road, Leamington, ON, N8H 5H7, CANADA; [2]Essex Region Conservation Authority, 360 Fairview Ave W, Essex, ON, N8M 1Y6, CANADA. **TP Concentrations in Essex County Streams: Greenhouse Farming Impacts and Mitigation Strategies.**

In 2016, the Leamington Area Tributaries were identified as a priority watershed for phosphorus reduction under Annex 4 of the Great Lakes Water Quality Agreement. Since 2012, we have been monitoring water quality in greenhouse (n=10) and non-greenhouse (n=5) influenced streams bi-weekly, year round. The average TP concentrations over the duration of this study (2012-2016) in non-greenhouse influenced streams were 7 times higher than the Provincial Water Quality Objective (PWQO) (0.03 mg/L) on average, while greenhouse influenced streams were 127 times the PWQO on average. As a result of this work, Ontario's greenhouse growers, in collaboration with the Ontario government, have worked to put in place policies and protocols to address all sources of potential nutrient loss. This includes, the regulation and monitoring of stormwater ponds, inclusion of greenhouse nutrient feedwater as a material to be land applied to agricultural crops, grower education and outreach, and municipal engagement. This in addition to a significant sector-led research program which has explored a number of options for on-farm solutions. Water quality monitoring will continue for several years to determine the effectiveness of these measures towards achieving a 40% reduction in phosphorus. *Keywords: Phosphorus, Greenhouse, Lake Erie, Harmful algal blooms.*

TED LAWRENCE, T.J., Great Lakes Fishery Commission, 2100 Commonwealth Blvd., Ste. 100, Ann Arbor, MI, 48105, USA. **Capacity Building of Africa's Future Fresh Water Scientists, Managers, and Politicians: A Proposal.**

Fresh water resources in Africa represent a major portion of the world's surface fresh water; they support millions of people, providing protein, clean water, and transportation. These resources also face common sets of challenges regarding management, climate change, agricultural runoff, deforestation, over harvest of fish, among others. It has been acknowledged that capacity building in developing countries face numerous challenges including underinvestment in universities and research institutions and limited access to research. Strengthening research capacity is one of the prerequisites for development goals to be met. This paper, therefore, suggests the establishment of an African Center for Aquatic Research and Education (ACARE). The call for such a center is not new and follows calls from the international community to create Centers of Excellence to address African issues.

This talk will describe ACARE's objectives, essential features, and scope of activities, and will investigate the potential and needs in terms of institutional arrangements, regional partners, funding options, available infrastructure, and the range of African and global water initiatives, both existing and anticipated, that can help build and sustain ACARE.
Keywords: Commons, Governance, Capacity building, Africa, Management.

TEPAS, K.M.[1], GREENE, A.M.[2], INSLEY, S.L.[3], OSANTOWSKI, E.S.[4], and WARMAN, M.L.[5], [1]IL-IN Sea Grant, 77 W. Jackson Blvd., Chicago, IL, 60604, USA; [2]Tecumseh Middle School, Medway, OH, USA; [3]North Olmsted Middle School, North Olmsted, OH, USA; [4]US EPA Great Lakes National Program Office, 77 W. Jackson Blvd, G-17J, Chicago, IL, 60604, USA; [5]Cleveland Metroparks, Cleveland, OH, USA. **Inspiring a New Generation of Aquatic Scientists!.**

Interested in inspiring the next generation in aquatic science? Start a water quality monitoring equipment loan program with real scientific equipment! Students are who are able to collect and analyze water-quality data from the field with actual equipment used by scientists are found to become especially engaged. This has been observed time and again with the Limno Loan program. This jointly run program, coordinated by Illinois-Indiana Sea Grant (with the Center for Great Lakes Literacy) and USEPA Great Lakes National Program Office, trains and then loans educators data sondes. Educators who have borrowed the equipment highly praise the opportunity, saying that using the data sonde "makes what the students are learning more real to them. They are engaged because they know they are using equipment used by scientists and they are doing the same job as a scientist." In this presentation, best management practices on how to run such a program will be covered. In addition, educators will provide first-hand accounts of how they have used the equipment in their teaching and the impact it has had on their students. Getting real monitoring equipment in the hands of students is a great way to bring water quality to life, get the students outdoors and grow the next generation of aquatic scientists. *Keywords: Environmental education, Water quality, Citizen science.*

TESFAYE, T.E., Eastern Nile Technical Regional Office (ENTRO), Addis Ababa, KENYA. **Collaboration through Libraries: The Impact of Digital Libraries for the Water Resources Development.**

The purpose of this study is to explore some of the major issues surrounding the development of digital libraries in The Nile Basin countries. The importance for digital libraries comes from the desire of knowledge sharing between these countries to become integrated as part of the cooperation for efficient utilization of the common Nile. As part of global information management trend, digital libraries technology holds the key to improve information access. Digital libraries provide increased access to global information and at the same time increase the visibility of indigenous information resources. The study looks at current state of ICT infrastructure, economic and data sustainability, issues of interoperability and the generation of local content, and the need to share information resources between the Nile Basin countries in order to improve the learning curve about hydrological, environmental and socio-economic nature of the common Nile. This study also covers research outputs publicly available online which can be queried, viewed and obtained in full for the digital library system. The study ends with a set of recommendations that can be used by information professionals and stakeholders in Nile Basin countries to organize the way forward of digital libraries as a means of cooperation for the common Nile. *Keywords: Africa, Track II Hydro-Poletics, Data storage and retrieval, Water distribution.*

TESHAGER, A.D.[1], MUENICH, R.L.[1], WANG, Y.C.[1], and SCAVIA, D.[2], [1]Graham Sustainability Institute, UofM, 214 S. State St., Ann Arbor, MI, 48104, USA; [2]Graham Sustainability Institute, UofM, 625 E. Liberty St., Suite 300, Ann Arbor, MI, 48104, USA. **Modeling St. Clair - Detroit River system watershed using the Soil and Water Assessment Tool (SWAT).**

St. Clair - Detroit River system watershed covers an area of about 19040 km^2 , including Lake St. Clair, of which 60% is in US and the other 40% is in Canada. About half of the watershed area is agricultural and a quarter of it is urban. The rest of the watershed area is grassland, waterbody, forest or wetlands. A project was initiated in June of 2016 to link stakeholders, science, and modeling across the watershed towards reducing harmful algal blooms and hypoxia conditions in Lake Erie. The Soil and Water Assessment Tool (SWAT) was used to develop a water quality model that integrates different components (agricultural, urban and Lake St. Clair) of the watershed. Data from the two countries have been harmonized to fit the model requirements. Moreover, various approaches have been utilized to integrate Lake St. Clair in the model set-up. The model was then calibrated and validated for flow and water quality for years 2001 to 2015. The calibrated model was then used to identify the major contributors of nutrients, mainly phosphorous, to Lake Erie. The next step is to develop various urban and agricultural management scenarios, through stakeholder engagement, aimed at reducing nutrient yields to inform policy. *Keywords: Watersheds, Water quality, Modeling.*

TESSIER, L.R. and WILKIE, M.P., Wilfrid Laurier University, 75 University Ave West, Waterloo, ON, N2L3C5, CANADA. **Gill Microenvironment Influences Lampricide Uptake and Clearance in Non-Target Fish.**

TFM (3-triflouromethyl-4-nitrophenol) is applied to streams of the Great Lakes where larval sea lampreys (*Petromyzon marinus*) are present. Non-target species (juvenile lake sturgeon and rainbow trout) may be exposed during treatments. TFM toxicity is dependent on its bioavailability; at lower pHs, higher proportions of un-ionized TFM are present and taken up through a mediated acid-base exchange process at the gills. Therefore, the gill microenvironment may affect TFM uptake and clearance. In this study, fish will be placed in a divided chamber and fitted with a latex mask, separating inspired and expired water, with surgically implanted pH opercular catheters. Fish will be exposed to radiolabeled TFM (14C-TFM) to track rates of TFM uptake and clearance. Simultaneously, metabolic rate measurements will be recorded via fiber optic O2 probes and compared to their ventilation strategies. Lake trouts have uni-directional respiration, where water is drawn through the mouth and irrigated over the gills. Lake sturgeons have ventrally-positioned mouths, uniquely adapted as bottom-dwellers. The mouth may be occluded during feeding, resulting in bi-directional ventilation. It is predicted that differences between these ventilation strategies may influence the gill microenvironment, resulting in differences in TFM toxicity.
Keywords: Fish toxins, Lampricide, Chemical analysis, Fish.

THEUERKAUF, E.J.[1] and NELSON, D.M.[2], [1]Illinois State Geological Survey, 615 E. Peabody Dr., Champaign, IL, 61820, USA; [2]Illinois Natural History Survey, 1816 South Oak Street, MC 652, Champaign, IL, 61820, USA. **Coupling Hydrodynamic Forces With Geomorphic Change Along the Illinois Lake Michigan Coast.**

Along the dynamic and highly urbanized Illinois Lake Michigan Coast protecting the remaining portions of natural habitat is a management priority. These habitats are located within Illinois Beach State Park (IBSP), where erosion and accretion, reduced littoral sediment supply, and unintended consequences of previous shore protection efforts have hindered management efforts over the past century. Results are presented here from a process-geomorphic study aimed at coupling physical drivers with coastal response at IBSP to improve management of the nearshore system. An analysis of aerial photography and data from previous studies revealed temporal and spatial variability in shoreline change rates and geomorphic change over the past century that is primarily related to shore-protective structures, lake level fluctuations, underlying geology, and storm events. Coastal changes at IBSP over the past 3 years are primarily a function of natural forces including near-record high lake levels, autumn storm waves, and persistent summer wind waves. Significant loss of habitat occurred during this time in response to rapid erosion (10-30 meters per year) and burial by overwash. Through development of a mechanistic understanding of the beach and nearshore system this work will guide solutions for protecting coastal ecological assets.

Keywords: Water level fluctuations, Storms, Shore protection, Beach erosion, Coastal processes, Coastal management.

THEYSMEYER, T., BOWMAN, J., and COURT, A., Royal Botanical Gardens, 680 Plains Rd West, Burlington, On, L7T4H4, CANADA. **20 Years of Progress Restoring River Mouth Marshes in the Hamilton Harbour AOC.**

Two of the three remaining river mouth marshes (Cootes Paradise Marsh and Grindstone Marsh) in the Hamilton Harbour Area of Concern were retained through protection within Royal Botanical Gardens' Nature Reserves, representing 95% of the remaining 300 ha of this habitat type. At the onset of the RAP in 1985 these marshes were almost totally devoid of aquatic plants, with only a remnants found, mostly in the outer delta of Grindstone Marsh. The impaired water quality conditions of the AOC allowed the Eurasian fish, Common Carp (*Cyprinus carpio*), to dominate and were a fundamental reason for the loss of river mouth marsh habitat. Common Carp exclusion has been implemented to protect the entire Cootes Paradise Marsh and the inner delta of Grindstone Marsh leaving the outer delta of Grindstone Marsh without exclusion. As of 2016 substantial improvements in aquatic vegetation and water quality have been realized in carp exclusion areas, while in the outer delta of Grindstone Marsh the aquatic environment has continued to decline, currently without aquatic plants. The ultimate goal for marsh sustainability is in restoring the altered environmental conditions that promoted the carp, addressing altered water cycles, eutrophication, and unmitigated urban stormwater runoff. *Keywords: Coastal wetlands, HHRAP, Lake Ontario, Cootes Paradise, Invasive species, Royal Botanical Gardens.*

THOMPSON, A.F.[1], RODRIGUES, S.N.[1], FOOKS, J.[1], BRUXER, J.K.[2], CALAPPI, T.J.[3], and OBERG, K.A.[4], [1]Environment and Climate Change Canada, 867 Lakeshore Road, Burlington, ON, L7S1A1, CANADA; [2]Environment and Climate Change Canada, 111 Water Street East, Cornwall, ON, K6H6S2, CANADA; [3]U.S. Army Corps of Engineers - Detroit District, 477 Michigan Avenue, Detroit, MI, 48226, USA; [4]U.S. Geological Survey, 405 N. Goodwin Avenue, Urbana, IL, 61801, USA. **Index-Velocity and Stage-Fall-Discharge Flow Computations for the St. Clair and Detroit Rivers.**

The ad-hoc Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data was established in 1953 with representatives of the Canadian and United States federal governments. One of its responsibilities is to develop coordinated estimates of the volume of water passing through the St. Clair and Detroit River system for the purposes of Great Lakes water level regulation, model simulations, forecasting and water balance calculations. St. Clair and Detroit River flows have historically been estimated from stage-fall-discharge relationships to account for variable backwater effects from Lake Erie and

Lake St. Clair. In 2008, index-velocity meters were installed in both rivers, presenting an alternative method for computing flows. A comparison of these two methods completed for the 2009-2015 time period shows that both methods produce similar results on a daily and monthly timescale. However, the index-velocity method offers additional advantages, including the ability to better account for fine scale transient flow conditions through increased resolution of flow computations, and the intrinsic ability to account for changes in resistance due to weeds or ice. This presentation will provide an overview of the comparison and findings of this analysis. *Keywords: Detroit River, Flow computations, St. Clair River.*

THOMPSON, P.A.[1], BOASE, J.C.[1], ROSEMAN, E.F.[2], DEBRUYNE, R.[3], BOWEN, A.K.[4], GORSKY, D.[5], MEHLER, K.[6], BURLAKOVA, L.E.[6], DROUIN, R.[7], SELZER, M.D.[8], and PRATT, T.C.[9], [1]U.S. Fish and Wildlife Service Alpena FWCO-Waterford Substation, Waterford, MI, USA; [2]U.S.G.S. Great Lakes Science Center, Ann Arbor, MI, USA; [3]University of Toledo, Department of Environmental Sciences, Toledo, OH, USA; [4]U.S. Fish and Wildlife Service Alpena FWCO, Alpena, MI, USA; [5]U.S. Fish and Wildlife Service Lower Great Lakes FWCO, Basom, NY, USA; [6]Great Lakes Center, Buffalo State College, Buffalo, NY, USA; [7]Lake Erie Management Unit Ontario Ministry of Natural Resources and Forestry, London, CANADA; [8]MI DEQ, Michigan Office of the Great Lakes, Lansing, MI, USA; [9]D.F.O. Canada Great Lakes Laboratory for Fisheries and Aquatic Sciences, Sault Ste. Marie, CANADA. **Great Lakes connecting channels: critical habitat and the need for research.**

The connecting channels of the Laurentian Great Lakes encompass over 1,100 kilometers of riverine and lacustrine water bodies, which are integral to the ecology and economies of the Great Lakes basin. The connecting channels follow the international border between Canada and the United States, flowing from Lake Superior to the Atlantic Ocean. The channels consist of four waterways: St. Marys, St. Clair-Detroit, Niagara, and St. Lawrence rivers. There are several shared attributes and resources among the connecting channels. For instance, the channels contain diverse fish communities, many species of conservation concern and provide resources for recreational and commercial fisheries. Because of their high socioeconomic importance, the regions surrounding the channels are areas of dense industrial and urban development. These combined stresses led to significant habitat degradation and the introduction of invasive species. The ecological, economic, and recreational resources within the connecting channels span multiple jurisdictional boundaries creating opportunities for collaborative restoration efforts. This poster highlights recent research and restoration activities along the Great Lakes connecting channels, and emphasizes the need to better understand the link between connecting channels and ecosystem services. *Keywords: St. Marys River, Niagara River, St. Clair River, St. Lawrence River, Detroit River.*

TILLITT, D.E.[1], SMITH, S.[2], NICKS, D.K.[1], RILEY, S.C.[3], RINCHARD, J.[4], HONEYFIELD, D.C.[5], and EVANS, A.N.[6], [1]U.S. Geological Survey, Columbia Environmental Research Center, Columbia, MO, USA; [2]Lynxnet Services, Columbia, MO, USA; [3]U.S. Geological Survey, Great Lakes Science Center, Ann Arbor, MI, USA; [4]Dept. Environ. Sci. Biology, The College at Brockport - State University of New York, Brockport, NY, USA; [5]U.S. Geological Survey, Northern Appalachian Research Branch, Leetown Science Center, Wellsboro, PA, USA; [6]Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR, USA. **Thiamine concentrations in lake trout eggs from the Great Lakes: current and past trends.**

Thiamine deficiency complex (TDC) in Great Lakes salmonines has been a primary cause for lack of natural recruitment and declines in certain populations. Indeed, in both Lake Huron and Lake Michigan, signs of natural recruitment in lake trout have only become evident after thiamine concentrations eggs increased to above the threshold of 4 nmol/g-egg. The importance of egg thiamine as a limiting factor in healthy lake trout populations led to the development of a monitoring program in 2001. Since that time, fisheries managers across the Great Lakes have worked with researchers to collect and measure egg thiamine concentrations. Here we report the trends in lake trout egg thiamine and compare those concentrations with measures of population status and natural recruitment.
Keywords: Biomonitoring, Vitamin B, Lake trout.

TISCHLER, Y.[1], DOYLE, T.[2], and MOLDAENKE, C.[1], [1]bbe Moldaenke GmbH, Preetzer Chaussee 177, Schwentinental, 24222, GERMANY; [2]PP Systems, 110 Haverhill Road, Suite 301, Amesbury, MA, 01913, USA. **bbe 10cells - Approved Measuring Instrument for the Indicative Investigation of Ballast Water.**

Due to International Maritime Organization's Ballast Water Convention (IMO-BWC) ballast water from ships has to be treated before discharge. The treatment aims to prevent the invasion of non-native organisms into waterbodies from lakes to oceans. Hence, suitable test devices for ballast water are required. Here, we introduce the 10cells, a mobile and robust fluorometer for the use in fresh water. The instrument quantifies microalgae based on chlorophyll fluorescence in less than one minute. Low-enriched algae on a filter are subjected to on-site analysis. The detection limit is one living cell/ml in the size range between 10 and 50 µm. Therefore 10cells is 10 times more sensitive than required by the IMO-BWC regulation D-2. Microalgae were selected as indicative organisms, because they present the predominant part of biomass in ballast water. Independent studies revealed the

suitability of the 10cells for ballast water investigation by comparing the fluorometer with different established laboratory methods. *Keywords: Ballast, Indicative test, Invasive species, Chlorophyll fluorescence, IMO.*

TITZE, D.T. and AUSTIN, J.A., Large Lakes Observatory, University of Minnesota Duluth, 2205 E 5th St, Duluth, MN, 55812, USA. **Sensitivity of Great Lakes Ice Cover to Air Temperature.**

Ice cover is shown to exhibit a strong linear sensitivity to air temperature. Upwards of 70% of ice cover variability on all of the Great Lakes can be explained in terms of air temperature alone, and these sensitivity relationships are remarkably similar among the three iciest Great Lakes. A difference in seasonally-averaged air temperature on the order of 1 to 2°C is, on average, the difference between a low- ice year and a moderate- to high- ice year. The total seasonal ice cover is most influenced by air temperatures during January, contemporaneous with the time of ice formation. Air temperatures during the fall and during the spring melting period were found to have little to no impact on total seasonal ice cover. Ice cover sensitivity relationships were compared between shallow coastal regions of the Great Lakes and similarly shallow smaller, inland lakes. It was found that the sensitivity to air temperature is similar between these coastal regions and smaller lakes, but that the absolute amount of ice that forms varies significantly between small lakes and the Great Lakes, and among the Great Lakes themselves. The Lake Superior application of the ROMS hydrodynamic numerical model corroborates a deterministic linear relationship between air temperature and ice cover, which is strongest around the period of ice formation.
Keywords: Ice, Atmosphere-lake interaction, Climate change.

TOTTEN, A.R. and DURIS, J.W., U.S. Geological Survey Lansing Water Science Center, 6520 Mercantile Way, Lansing, MI, 48911, USA. **Distribution of Phosphorus and Velocities in Southern Trenton Channel, Detroit, Michigan 2014-2015.**

The Trenton Channel is a 13-kilometer long conveyance along the west side of the Detroit River between mainland of Michigan and Grosse Ile. Trenton Channel is part of the Detroit River Area of Concern largely as a result of urban and industrial discharges, and storm water runoff. From November 2014 to November 2015, the U.S. Geological Survey (USGS) conducted a study to better examine flow dynamics and nutrient concentrations in the southern portion of the Trenton Channel. A series of samples were collected at various depths and horizontal locations along a cross section at the Trenton Channel. Results from samples taken along that section indicate a factor of two difference between mean phosphorus concentrations near the west side of the channel (0.027 mg/L) than the east side of the channel (0.014 mg/L). Acoustic Doppler Current Profiler (ADCP) streamflow

measurements were taken immediately after sampling to determine velocity (avg. 0.65 m/s) and discharge (avg. 1365 m^3/s) for the cross-section. ADCP data shows an area of higher than average velocity approximately 200 meters from the west side of the channel (0.98 m/s) and relatively uniform velocity throughout the rest of the channel. The combination of intensive discrete depth samples and ADCP data can help develop future load estimations for Trenton Channel. *Keywords: Great Lakes Restoration Initiative (GLRI), Velocity Mapping, Water quality, Lake Erie, Phosphorus.*

TOUSSANT, C.A., U.S. Geological Survey, 6460 Busch Blvd, Columbus, OH, 43229, USA. **Evaluating Agricultural Conservation Practices through edge-of-field monitoring in the Great Lakes.**

The Great Lakes Restoration Initiative (GLRI) Priority Watersheds program is an inter-agency effort that seeks to accelerate ecosystem restoration in the Great Lakes by confronting threats to the region, such as non-point source pollution. Four Priority Watersheds in five states: Fox River/Green Bay in Wisconsin, Saginaw River in Michigan, Maumee River in Ohio and Indiana, and the Genesee River in New York have been targeted as having a high density of agricultural land use and clearly identifiable ecosystem impairments. The U.S. Department of Agriculture Natural Resources Conservation Service, U.S. Environmental Protection Agency, and the U.S. Geological Survey (USGS) have partnered to track GLRI program accomplishments on a selective number of privately owned farms applying agricultural conservation practices. Monitoring methods follow previous USGS approaches, targeting study locations within watersheds areas directly affected by conservation efforts. This presentation will review the results from the edge-of-field scale and the approaches used to evaluate conservation practice efficiencies. The runoff-quality conditions and timing, as well as potential water quality improvements will be identified and how this type of information can be used to inform conservation will be described. *Keywords: Conservation, Great Lakes Restoration Initiative (GLRI), Monitoring.*

TRAN, K. and ACKERMAN, J.D., University of Guelph, Guelph, ON, CANADA. **Differences in the Feeding of Sympatric Freshwater Mussels May Indicate Resource Partitioning.**

The manner in which diverse mussel species coexist in the Great Lakes watershed remains uncertain. The clearance rate (CR) of 3 co-occurring mussel species (Potamilus alatus, Quadrula quadrula and Ptychobranchus fasciolaris) on river seston from the Sydenham River was examined under static conditions in tanks and under high flux conditions in a flow chamber. The CR was measured using the differences in water samples collected at the beginning vs. the end of each feeding experiment using a calibrated fluorometer (for chlorophyll a) and an imagining flow cytometer, which enabled us to identify 11 major algal taxa. CR obtained using the fluorometer was higher at high vs. no flux with the exception of P. alatus. Differences in algal-specific CR were observed among the mussel species: P. fasciolaris had the highest CR for 4/9 taxa (no flux) and 6/11 (high flux), Q. quadrula had 3/9 and 3/11; and P. alatus had 2/9 and 2/11. Electivity indices are being applied to determine the selectivity of algal species by the mussels. Differences in feeding ability among the mussel species indicate possible resource partitioning, providing evidence for coexistence. Further understanding of mussel feeding requirements will benefit conservation. *Keywords: Algae, Diets, Distribution patterns.*

TREBITZ, A.S.[1], COTTER, A.[1], OPSETH, A.[1], SCOFIELD, A.E.[2], and HOFFMAN, J.C.[1], [1]U.S.EPA Mid Continent Ecology Division, Duluth, MN, USA; [2]Cornell University, Ithaca, NY, USA. **Spatial and temporal water quality patterns in open-water Lake Michigan from the 2015 CSMI.**

Water quality patterns in the Laurentian Great Lakes broadly reflect climate, surficial geography, and landuse but are also shaped by limnological and biological processes. Open-water sampling conducted as part of the 2015 Lake Michigan interagency coordinated science and monitoring initiative (CSMI) at 3 depths along 8 transects over 3 time periods provides an opportunity to examine water quality patterns over large spatial scales and hydrologically active time periods. Sampling stations were unstratified but showing surface warming in May, and stratified with elevated metalimnetic nutrients and chlorophyll at deeper stations in July and September. Significant spatial patterns (e.g., north vs south, shallow vs. deep) were observed in some but not all sampling periods, and patterns in CHLA were not necessarily concordant with nutrients. Consistent with recent trends, we find that open waters remain generally oligotrophic in both TP and CHLA. Biological composition changes may be driving a temporal offset between nutrient maxima during spring isothermal conditions and CHL maxima during summer-stratification. *Keywords: Water quality, Lake Michigan, Assessments.*

TREEMORE-SPEARS, L.J., Wayne State University, 5050 Anthony Wayne Drive, 2157 Engineering, Detroit, MI, 48202, USA. **The Role of Partnerships in Urban Field Research.**

The Huron to Erie Alliance for Research and Training (HEART) is a multi-disciplinary and multi-institutional alliance of public universities and agencies that work together on applied water-related research, education and training. With a network of researchers and practitioners that are active in the many urban areas along the water corridor from Lake Huron to Lake Erie and three field stations from Lake St. Clair to Detroit, this

system provides a model for collaborative research across disciplinary and institutional boundaries. Led by the Healthy Urban Waters program at Wayne State University, the collaborative effort benefits from an anchor institution with dedicated staff. Field research that is being conducted in the urban areas surrounding the HEART field stations addresses topics relating to water infrastructure (drinking water, storm water and waste water), invasive species (in the environment, and in regulatory systems such as for shipping ballast water), public health, hydraulic and hydrologic processes (urban flooding and climate change), the blue economy (fisheries and tourism), and technology (big-data water monitoring systems). This presentation provides an overview of current work and collaborative structures, and invites an opportunity to discuss other models being employed elsewhere.
Keywords: Environmental contaminants, Invasive species, Urban watersheds, Human health, Education, Water quality.

TREMONTI, A.R.[1], PITTS, D.K.[2], HASHEMI, P.[3], and MCELMURRY, S.P.[1], [1]Department of Civil and Environmental Engineering, Wayne State University, Detroit, MI, 48202, USA; [2]Department of Pharmaceutical Sciences, Wayne State University, Detroit, MI, 48202, USA; [3]Department of Chemistry, University of South Carolina, Columbia, SC, USA. **Sublethal Cu effects on photo stimulated neurotransmitter release in *Daphnia magna* using FSCV.**

Copper (Cu) is a freshwater contaminant that is fundamentally persistent once introduced into the environment. Although Cu toxicity has been studied for decades, there is a continuing problem with new sources and pathways. Novel approaches are required to understand its potential for complex biological interactions. Fast scan cyclic voltammetry (FSCV) is a powerful new method for measuring electroactive species with high sensitivity and sub-second temporal resolution. This analytical technique is shown to have the ability to detect a light-sensitive neurotransmitter release in the microcrustacean, *Daphnia magna*. A carbon fiber microelectrode was positioned in the *Daphnia* brain and neurotransmitter release was measured using two optimized waveforms, one for histamine and one for serotonin. Light-sensitive neurotransmitter release was detected using both waveforms. When exposed to a sub-lethal (0.1 μM) Cu exposure for a short duration (30 min), *Daphnia* negative-phototactic response for serotonin was altered with a significant reduction in photo stimulated neurotransmitter release ($p<0.001$). This suggests that serotonin may be involved in the effects of Cu on negative phototactic behavior. The FSCV technique is capable of advancing knowledge of complex Cu interactions and the impact of sublethal toxicity.
Keywords: Copper, Cyclic voltammetry, Pollutants, Neurotransmitter, Environmental contaminants, Sublethal effects.

TRIEZENBERG, H.A.[1], CRONK, K.R.[1], BURLEW, S.A.[2], PIWARSKI, J.R.[3], GOERING, D.C.[4], HOULE, L.S.[4], HINTZEN, K.D.L.[1], and BARTHOLIC, J.F.[3], [1]Michigan Sea Grant/MSU Extension, 1405 S. Harrison Rd. Suite 305 Manly Miles, East Lansing, MI, 48823, USA; [2]Michigan State University Extension, 20 Care Dr., Suite B, Hillsdale, MI, 49242, USA; [3]Institute for Water Research, 1405 S. Harrison, Suite 101, East Lansing, MI, 48823, USA; [4]National Weather Service North Central Forecast Center, 1733 Lake Drive West, Chanhassen, MN, 55317, USA. **Overview of runoff risk forecasting tools under development in the Great Lakes Basin.**

Manure runoff from agricultural sources is associated with increased nutrient loading and associated harmful algal blooms in the Great Lakes. The Runoff Risk Advisory System is forecasting tool that is under development in Michigan to help livestock producers, irrigation operators, and others consider the runoff risk associated with manure and other applications given weather and soil condition forecasts. This presentation will provide an overview of the Runoff Risk Advisory Forecast Tool, insights into the data modeling forecasts, automated notifications, current training and educational efforts, and expected outcomes from adoption of this tool. Project collaborators are: NOAA National Weather Service, Sea Grant, MSU Extension, Michigan Department of Agriculture and Rural Development, Michigan Department of Environmental Quality, MSU Institute of Water Research, and others. Currently, the Runoff Risk tool exists in Wisconsin, and it is under development in other states. *Keywords: Nutrients, Great Lakes basin, Outreach.*

TROY, C.D.[1] and CHOI, J.M.[2], [1]Purdue University, 550 Stadium Mall Drive, West Lafayette, IN, 47907-2051, USA; [2]Georgia Tech, Atlanta, GA, USA. **Lateral dispersion of dye and drifters in the center of Lake Michigan.**

We report results from two lateral dispersion experiments carried out in the offshore surface waters of Lake Michigan's southern basin during the stratified period: (1) a day-long dye tracking experiment; and (2) a 24 day long drifter tracking experiment. Both the dye patch and drifters were surface-released at the center of Lake Michigan's southern basin, in 153 m depth water, in early June 2013. Near-surface currents were dominated by near-inertial energy for the duration of the experiments and the formation of the mixed layer corresponded with increased high-frequency surface energy. Comparison between drifter and dye data during the first day reveal the importance of vertical shear in enhancing lateral dispersion for the low-energy conditions; lateral dispersion rate from the short dye experiment showed was 3.5m^2/s, with the dye cloud spreading to a size of 2.4km after a day. The drifter cluster dispersed at a much lower rate. Elevated dispersion was observed as the drifter cluster interacted with a thermal front. Comparisons with recent dispersion measurements in the Gulf of Mexico suggest very low rates of dispersion in the surface

waters of even very large lakes, relative to ocean systems. *Keywords: Lake Michigan, Turbulence, Toxic substances, Dispersion, Mixing.*

TRUESDELL, S.B. and BENCE, J.R., Michigan State University Quantitative Fisheries Center, 375 Wilson Rd., UPLA Room 101, East Lansing, MI, 48824, USA. **A comparison of catch-at-age and catch-at-size fish stock assessment models.**

Catch-at-age and catch-at-size models are often used by fishery scientists to estimate population rates and states for the purpose of management advice. These dynamic models integrate time series data such as fishery catch, survey catch-per-effort and fishing effort to estimate parameter values that are optimized using maximum likelihood. Age-structured analyses are typically used to model fish populations that have regularly collected age samples (e.g., otoliths or scales), however most fishery processes (e.g., selectivity) are size- rather than age-based. Size-structured models have the benefit of natural integration into size-based population and fishery dynamics but they require a growth transition matrix that is usually inestimable inside an assessment model. This research (1) discusses the pros and cons of age- and size-structured models; (2) compares model performance under simulated scenarios; and (3) offers advice as to when size-structured approaches should be pursued. *Keywords: Stock assessment, Population dynamics.*

TRUMPICKAS, J.[1], RENNIE, M.D.[2], and DUNLOP, E.[1], [1]Ontario Ministry of Natural Resources and Forestry, 2140 East Bank Dr, Peterborough, ON, K9L1Z8, CANADA; [2]Lakehead University, 955 Oliver St, Thunder Bay, ON, P7B5E1, CANADA. **60 Years of Foodweb Change in South Bay, Lake Huron.**

Numerous stressors impact the fish community of Lake Huron. By studying the fish community of a Lake Huron embayment (South Bay), which has one of the longest-running fish community surveys in the Great Lakes, we can gain perspective on the changes to the food web caused by a variety of stressors over time. Previous research has shown that isotopes can be reliably estimated from fish scales, providing information about trophic level, diet, and the source of food (i.e. nearshore vs offshore). Building from this research, we measured stable isotopes (C13 and N15) from archived scale samples from numerous species collected from the 1940s-2010s, allowing us to re-create the food web structure of the South Bay community over a broad time frame. Isotope ratios from typically offshore species (Alewife, Cisco, Lake trout, Lake Whitefish, Rainbow Smelt) and nearshore species (Smallmouth Bass, Rock Bass, White Sucker, Yellow Perch) were measured, totaling approximately 2000 fish. The results of the isotope analysis provide insight on how stressors have affected the Lake Huron food web through a number of trophic levels, while allowing us to identify time periods of diet changes and trophic shifts. Notably, the results also

suggest potential impacts of ongoing and future stressors. *Keywords: Lake Huron, Fish, Isotope studies.*

TSEHAYE, I.[1], HANSEN, S.[1], and TRESKA, T.J.[2], [1]Wisconsin Department of Natural Resources, 2801 Progress Road, Madison, WI, 53716, USA; [2]US Fish and Wildlife Service, 2661 Scott Tower Dr, New Franken, WI, 54229, USA. **Sensitivity of Green Bay lake whitefish catch-at-age model estiamtes to gear selectivity assumptions.**

Few studies evaluated the consequences of model misspecification for commonly used stock assessment approaches. We assessed the sensitivity of model predictions to assumptions of commercial and recreational gear selectivity using a statistical catch-at-age model for lake whitefish in Wisconsin waters of Green Bay and Lake Michigan. The model was fit to harvest, age composition, and effort data from gillnet and trap net commercial (1989-2015) and recreational (ice) (2007-2015) fisheries under various combinations of time-varying and time-invariant selectivity functions: time-varying (random-walk) selectivity for commercial fisheries and fixed selectivity for recreational fisheries, time-varying selectivity for both fisheries, random-walk selectivity in two time blocks for commercial fisheries and fixed or time-varying selectivity for recreational fisheries. Annual abundance estimates varied greatly (in some cases by >50%) depending on assumptions of gear selectivity, suggesting that selectivity misspecification can impact estimates of management quantities. Model predictions were more stable when lower weights were assigned to recreational fisheries data, which were less comprehensive. Our results highlighted that estimating selectivity requires a clear understanding of underlying fishery characteristics and reliable data. *Keywords: Fish populations, Green Bay, Assessments.*

TUCHMAN, M.L. and CIENIAWSKI, S.E., U.S. EPA Great Lakes National Program Office, 77 W. Jackson Blvd, Chicago, IL, 60604, USA. **US EPA's Great Lakes Legacy Act: 12 Years of Progress Remediating Contaminated Sediments at AOCs.**

In November 2002, U.S. EPA's Great Lakes Legacy Act (GLLA) was signed into law with the specific intent to remediate contaminated sediments at Great Lakes Areas of Concern (AOCs). Before GLLA, only limited progress had been made in addressing contaminated sediments, a major, intractable issue impacting 9 of the 14 listed Beneficial Use Impacts (BUIs) at AOCs. Since GLLA funding commenced in 2004, EPA has worked with a variety of state, local, and private partners to fund over $580 million of contaminated sediment work, resulting in the remediation of over 4,000,000 cubic yards of contaminated sediments across 21 remediation projects. Approximately $350 million of federal funding has leveraged over $230 million in non-federal funds to implement a highly successful sediment remediation program with planning, evaluation, and remediation projects across 19 AOCs and 7 Great Lakes states. The authors present an introduction to the GLLA program, a retrospective of the completed remediation projects, and a summary of the benefits AOCs have obtained from the completed sediment remediation work. *Keywords: Sediments, Areas of Concern.*

TUCKER, A.J.[1], CHADDERTON, W.L.[1], DAVIDSON, A.D.[2], and KASHIAN, D.R.[2], [1]The Nature Conservancy, South Bend, IN, USA; [2]Wayne State University, Detroit, MI, USA. **Application of a Watch List to Inform AIS Surveillance in the Laurentian Great Lakes.**

A Great Lakes Aquatic Invasive Species Interstate Surveillance Framework (the Framework) has been drafted to address the regional goal of establishing a comprehensive program for detecting and tracking newly identified aquatic invasive species (AIS) in the United States' waters of the Laurentian Great Lakes. As part of the Framework, a Great Lakes surveillance watch list based on pathway-, vector-, and taxon-specific risk assessments was completed using the Great Lakes Aquatic Nonindigenous Species Information System (GLANSIS). Here we discuss how data from the watch list species' risk assessments were used to identify and quantify the relative risk of introduction from pathways associated with high and moderate risk AIS, and how the information was applied to prioritize locations where surveillance efforts are most likely to detect these or similar high risk species. The watch list risk assessment data can also be used to inform decisions around which habitats need to be sampled and what sampling methods should be deployed to maximize detection sensitivity and the probability that new introductions of high risk AIS are detected early. Finally, we discuss how the data provide a resource that can be used to inform response efforts should a watch list species be detected. *Keywords: Invasive species, Surveillance, Risk assessment, Great Lakes basin.*

TUGYI, N., KOVÁCS, A., VÖRÖS, L., TÓTH, V., and SOMOGYI, B., Balaton Limnological Institute, Centre for Ecological Research, Hungarian Academy of Sciences, Tihany, HUNGARY. **Phyto- and Bacterioplankton Production in a Shallow Central European Great Lake (Lake Ferto Hungary).**

Lake Ferto (Hungary/Austria) is a shallow, eutrophic, steppe lake in central Europe. Half of the lake is covered by reed, forming numerous brown-water ponds (inner lakes) of variable size. In macrophyte-dominated shallow lakes, the activity of bacterioplankton is largely unknown. The aim of our study was to determine the role of bacterioplankton and to assess how heterotrophic production relates to total primary production in a large shallow lake. Production was measured in the open water and in the reed belt monthly between October 2015 and September 2016. Primary production was determined from radiolabeled C

uptake and bacterial production from tritiated leucine incorporation. Microbial activity showed seasonal dynamics, the highest values measured in the warmer months. Phytoplankton production was higher in the open water (53-460 mg $C/m^2/d$) than within the reed belt (9-290 mg $C/m^2/d$). In contrast, the production of the bacterioplankton was higher within the reed belt (10-340 mg $C/m^2/d$) than in the open water (17-226 mg $C/m^2/d$). Our results suggest that bacterioplankton assume a more active role in the littoral zone (reed belt) of Ferto than in the open water and that DOC originating from aquatic macrophytes is an important carbon source for bacterioplankton in shallow lakes.
Keywords: Productivity, Macrophytes, Photosynthesis.

TURNER, A.J. and DE LOË, R.C., University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L3G1, CANADA. **Thinking Outside the "Water Box" in the Detroit River Area of Concern.**

Many long-standing water problems persist around the world despite sustained attention from water practitioners over decades. Weak governance arrangements are a key contributing factor. Water governance often is based on water-centric problem framings that do not take sufficient account of the role of external actors, institutions, and drivers. Recognition of this problem is growing, but identifying external connections and then addressing the critical ones is challenging for water managers. This research uses a practical and flexible diagnostic approach that can be implemented by researchers, practitioners, or both together. This diagnostic approach is applied to the Detroit River Area of Concern, in both the United States and Canada, to determine critical external connections present in each nation that affect the river both during and after delisting. The preliminary analysis reveals that while a water-centric problem framing is appropriate during delisting, external connections could become important after delisting. Potentially relevant external connections include population and economic shifts, land use change, the health of adjacent waterways, large-scale environmental change, funding, recognition, and public engagement.
Keywords: Detroit River, Decision making, Water quality.

TURNQUIST, K.N.[1], LARSON, W.A.[2], BRONTE, C.R.[3], HANSON, S.D.[3], STOTT, W.[4], and SLOSS, B.L.[5], [1]Wisconsin Cooperative Fishery Research Unit, University of Wisconsin-Stevens Point, 800 Reserve Street, Stevens Point, WI, 54481, USA; [2]U.S. Geological Survey, Wisconsin Cooperative Fishery Research Unit, 800 Reserve Street, Stevens Point, WI, 54481, USA; [3]U.S. Fish and Wildlife Service, Green Bay Fish and Wildlife Conservation Office, 2661 Scott Tower Rd., New Franken, WI, 54229, USA; [4]Great Lakes Science Center, Department of Fisheries and Wildlife, Michigan State University, 1451 Green Rd., Ann Arbor, MI, 48105, USA; [5]College of Natural Resources, University of Wisconsin-Stevens

Point, 800 Reserve Street, Stevens Point, WI, 54481, USA. **Genetic Heritage of Naturally Produced Lake Trout in Lake Michigan.**

Lake Trout (*Salvelinus namaycush*) recently began reproducing and recruiting in southwestern Lake Michigan at low levels. To increase diversity and the potential for reproduction, restoration strategies have relied on stocking six hatchery strains: Seneca Lake, Lewis Lake, Green Lake, and Marquette, Apostle Island, and Isle Royale from Lake Superior. Our goal was to determine which strains have contributed to the observed natural reproduction to help guide future stocking efforts. Our objectives were to 1) identify a subset of microsatellite markers that reliably delineate strain of origin for the six Lake Trout strains stocked into Lake Michigan, and 2) determine if the genetic markers and reference data are capable of diagnosing the genetic heritage of interstrain crosses and wild caught Lake Trout. Thirty-six previously developed microsatellite loci were used to delineate the six reference strains using program STRUCTURE. One thousand individuals were simulated for all possible combinations of F1 pure and interstrain crosses, and strain of origin of the simulated individuals was estimated using STRUCTURE. The reference data were used to assess genetic heritage of wild caught Lake Michigan Lake Trout, and identified the Seneca Lake strain as the major contributor to Lake Michigan natural reproduction.
Keywords: Genetics, Lake Michigan, Lake trout.

TURSCHAK, B.A.[1], GRUNERT, B.[2], and BOOTSMA, H.A.[1], [1]UWM-School of Freshwater Sciences, 600 E Greenfield Ave, Milwaukee, WI, 53204, USA; [2]MTU-Department of Geological and Mining Engineering and Sciences, 1400 Townshend Dr, Houghton, MI, 49931, USA. **Effects of Ecology and Biogeochemistry on the Stable Isotopes of Nearshore Fishes in Lake Michigan.**

In large lakes, such as the Laurentian Great Lakes, spatial gradients in chemical cycling, physical processes, and fluvial inputs may result in major spatial differences in carbon input at the base of the food web, which may in turn affect the diets of higher trophic levels. We examined the diets of four species of Lake Michigan nearshore fishes using stable carbon and nitrogen isotopes across eight study sites around the lake and combined these data with MODIS level 2 $K_d(490)$ light extinction data. Using this two-pronged approach, we were able to better understand whether regional differences in biogeochemistry or trophic structure resulted in apparent isotopic variation. Large scale spatial differences in $\delta^{13}C$ and the diet of Lake Michigan nearshore fishes were correlated with $K_d(490)$. However, responses of individual fish species were variable and dependent on the organism's feeding ecology. We hypothesize that variation in the light environment results in regional differences in primary productivity, with effects being propagated through other food web components. Our results highlight the advantages of considering both satellite imagery and conventional trophic indicators to understand large-scale spatial patterns of food web structure. *Keywords: Stable isotopes, Fisheries, Remote sensing.*

TUTTLE, T.A.[1], DAVIS, T.W.[2], MCKAY, R.M.L.[1], and BULLERJAHN, G.S.[1], [1]Bowling Green State University, Life Sciences Building, Bowling Green, OH, 43403, USA; [2]NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Road, Ann Arbor, MI, 48109, USA. **Understanding Drivers of Bloom Toxicity by Quantifying Toxic Strains of Planktothrix in Sandusky Bay.**

Sandusky Bay (OH) is a shallow, often N-depleted embayment of Lake Erie dominated by blooms of the toxic cyanobacterium *Planktothrix*. Prior work has shown that *Planktothrix* is adapted to N-depletion arising from active denitrification. Indeed, ratios of DIN:DIP in 2015 fell below 16 in late summer and to below 2 in 2016. To characterize seasonal changes in the *Planktothrix* population, quantitative (q)PCR was conducted on samples collected during summers 2015 and 2016 to determine the abundance of toxic *Planktothrix* in the Bay. Despite large differences in nutrient loading from 2015 to 2016, *Planktothrix* was the dominant bloom taxon. Ratios of toxic-to-non-toxic genotypes varied spatially and temporally both years. Samples with high abundances of toxic cells typically had low toxin concentrations. Some samples had a low abundance of toxic *Planktothrix*, yet showed high microcystin concentrations, suggesting a possible minor genotype producing large amounts of microcystin. Environmental parameters were analyzed with the qPCR results to determine drivers responsible for genotypic dominance. In particular, taxonomy correlated with N speciation, temperature and SRP. Metatranscriptome data from the 2015 bloom season allowed additional functional profiling of N cycling and toxin production. *Keywords: Harmful algal blooms, Cyanobacteria, Lake Erie, Nutrients.*

TUTTLE-RAYCRAFT, S. and ACKERMAN, J.D., University of Guelph, 50 Stone Road East, Guelph, ON, N1G2W1, CANADA. **The effect of suspended sediment flux on the feeding and gill morphology of a freshwater mussel.**

How mussels are able thrive in turbid rivers is not well understood. The effect of suspended sediment flux (SSF) on the suspension feeding of the freshwater mussel *Lampsilis siliquoidea* from a clear water vs. a turbid population was examined in a flow chamber using combinations of sediment concentration (C) and velocity (U). The clearance rate (CR) response to SSF varied on the U vs. C response surface, but differed between turbid vs. clear populations. The turbid river mussels were less affected by SSF; i.e. there was a 5% vs. 31% reduction in CR of the populations at 25 000 mg m^{-2} s^{-1} (high C x high U). The most likely mechanism for this is the difference in gill and palp morphology found using SEM. The palp to gill ratio was significantly higher for turbid vs clear water animals, which also had significantly more cirri per linear cm of gill and cilia per cirri of the gill. These gill markers indicate that the mussels from the turbid river are more effective at particle sorting. The increased particle sorting ability of animals from turbid vs clear rivers may explain why they are less affected by SSF, and how mussels thrive in these habitats. *Keywords: Unionids, Habitats, Turbidity.*

TWISS, M.R.[1], SKUFCA, J.D.[1], SHIRKHANI, H.[2], RUSSO, A.M.[1], LUMBRAZO, C.[1], NEFF, F.C.[1], SPRAGUE, H.[1], LOFTUS, S.E.[1], and RIDAL, J.J.[2], [1]Clarkson University, Potsdam, NY, 13699, USA; [2]St. Lawrence River Institute for Environmental Sciences, Cornwall, ON, K6H 4Z1, CANADA. **Novel sensor deployments in a hydropower dam on the Saint Lawrence River.**

The Upper Saint Lawrence River (USLR) is a 100 km long, high volume discharge (6,800 m^3/sec) river and the only natural discharge from the Great Lakes. The Moses-Saunders hydropower dam (est. 1958; Canada, USA) regulates water levels and impacts ecosystem integrity in the USLR. Water quality sensors (chl-a, phycocyanin, CDOM, °C, turbidity, specific conductivity) have been installed in the dam in three locations to reflect water quality in the nearshore and main channel zones of the river. Water from passes through sensor arrays at 10 L per minute and data are gathered at 1 minute intervals. Hydrodynamic water flow modeling indicates that these sensor locations measures distinct zones in the river. Compared to other methods for measuring water quality in the river at high spatial scales, e.g. main channel and nearshore transects or transverse transects, the dam placed sensors do not have the same spatial resolution but instead rely on hydrodynamic modeling to show where water sensed at the stations has passed. However, dam-placed sensors operate year-round and thus have superior temporal resolution and the ability to indicate a wide range of short-term (e.g., storm) and long-term changes (annual) in water quality that can be used to support Adaptive Management actions in the USLR. *Keywords: St. Lawrence River, Water quality, Data acquisition.*

U

URBAN, N.R., LIN, H., PRIYADARSHINI, M., and PERLINGER, J.A., Michigan Technological University, 1400 Townsend Dr., Houghton, MI, 49931, USA. **Spatial and Temporal Variability in PCB Concentrations in Lake Trout from Lake Superior.**

It is frequently reported that PCB concentrations in Great Lakes fish declined rapidly after 1979, but recent rates of decline are slowing. We analyzed fish contaminant data from five agencies (> 15 sampling locations) to evaluate recent trends as well as spatial variability

in Lake Superior fish. For two agencies, analytical changes coincided with large drops in concentrations, and for a third agency coincided with a decline in variability of results. The rate of decline since 1995 has slowed to half-lives of 26-95 yrs, and rates of decline were not significant at three of seven sites. This contrasts with a nearly constant half-life of 19 years for PCBs in atmospheric deposition to L. Superior since 1991. There are large differences (up to 5-fold) in concentrations among sites, and large short-term fluctuations in concentrations are observed at most sites. Some inter-site differences were correlated with differences in growth rates, but there was no systematic trend in growth rates over time, and fluctuations in growth rate could not explain short-term fluctuations in PCB concentrations. Analytical differences among agencies prevent comparison of congener patterns among all sites; congener patterns at two sites show differences attributed to food web structures.
Keywords: Fish, PCBs, Lake Superior.

UZARSKI, D.G.[1], BRADY, V.J.[2], and COOPER, M.J.[3], [1]Institute for Great Lakes Research and CMU Biological Station, Central Michigan Univertisy, Mount Pleasant, MI, USA; [2]Natural Resources Research Institute, University of Minnesota, Duluth, MN, USA; [3]Burke Center for Freshwater Innovation, Northland College, Ashland, WI, USA. **The Great Lakes Coastal Wetland Monitoring Program: Seven Years of Implementation.**

Since European settlement, over 50% of coastal wetlands have been lost in the Laurentian Great Lakes basin, causing growing concern and increased monitoring by government agencies. For over a decade, monitoring efforts have focused on the development of regional and organism-specific measures. To facilitate collaboration and information sharing between public, private, and government agencies throughout the Great Lakes basin, we developed standardized methods and indicators used for assessing wetland condition. Using an ecosystem approach and a stratified random site selection process, birds, anurans, fish, macroinvertebrates, vegetation, and physico-chemical conditions were sampled in coastal wetlands of all five Great Lakes including sites from the United States and Canada. Our primary objective was to implement a standardized basin-wide coastal wetland monitoring program that would be a powerful tool to inform decision-makers on coastal wetland conservation and restoration priorities throughout the Great Lakes basin.
Keywords: Coastal wetlands, Monitoring, Ecosystem health.

UZARSKI, D.R.[1], MICHAUD, G.[1], DONNER, K.[2], SCHUBERG, D.[1], and GALAROWICZ, T.L.[1], [1]Institute for Great Lakes Research, CMU Biological Station and Dept. of Biology, Central Michigan University, Mount Pleasant, MI, 48859, USA; [2]Little Traverse Bay Bands of Odawa Indians, 7500 Odawa Circle, Harbor Springs, MI, 49740,

USA. **An Evaluation of Lake Whitefish Nursery Habitat: Beaver Island, Lake Michigan.**

Lake whitefish, Coregonus clupeaformis, support one of the most valuable commercial fisheries in the Great Lakes. Over the last decade lake whitefish have experienced a steady decline in recruitment. The shallow, rocky waters north of our sites on Sand Bay, Beaver Island, MI., were thought to be the major spawning area of the region. When larvae emerge in the spring, currents distribute them to potential nursery areas. Nursery areas must provide food and protection from storm surges and predation. Two potential nursery sites were selected as part of a much larger collaborative study. Fish were collected using a 30m seine in early and late June from 2014 to 2016. Three replicate hauls were made 50m apart at each site. All individuals were identified and enumerated. Chemical and physical parameters were measured in conjunction with biotic samples. The greatest total number of fish and the most whitefish were caught at the northern most site. The northern site was shallower, more protected, and had a sandier substrate than the southern site. Whitefish growth rates were also slightly greater at the northern site (0.663mm/day and 0.546mm/day respectively). While very close in proximity, the more benign site seemed to provide better nursery habitat. *Keywords: Fisheries, Fish populations, Coastal ecosystems.*

V

VADEBONCOEUR, Y., GAINES, E.I., and KENYON, L.O., Wright State University, 3640 Colonel Glenn Hwy, Dayton, OH, 45435, USA. **Bringing the science of communication to communicating science: an evaluation of an outreach product.**

Using our research in Lake Tanganyika, East Africa as context, we created a website (intotherift.org) to educate the public about the importance of intact ecosystems for human well-being. The informal science education content was targeted at teens (12-18 y). A primary goal was to portray science as an activity that was inviting and accessible to girls and underrepresented minorities. We developed an inquiry-based 10th grade curriculum for teachers to use in conjunction with the website for formal classroom instruction. The presentation will evaluate lessons learned during the development and launch of the outreach project. We will discuss the efficacy of a web-based "virtual field trip" as a pedagogic tool for teaching science, as opposed to simply increasing awareness of science. The interactive website is visually appealing and informative. However, in order to evaluate the impact of the website, we needed a more intentional integration of assessment tools throughout its development. Developing technologies provide exciting new opportunities that can increase access to science and scientists. Nevertheless, the impact and success of outreach projects depend on the successful incorporation of established pedagogic and communication practices into web-based learning platforms. *Keywords: Outreach, Website, Africa, Environmental education.*

VAIL, J.H.[1] and STEWART, S.R.[2], [1]Grand Valley State University Annis Water Resources Institute, 740 W. Shoreline Drive, Muskegon, MI, 49441, USA; [2]Michigan Sea Grant Extension, 21885 Dunham Road, Suite 12, Clinton Township, MI, 48036, USA. **Great Lakes Public Engagement through Shipboard Programs.**

A hallmark of the 2012 Great Lakes Water Quality Agreement (GLWQA) is "Public engagement - incorporating Public opinion and advice, as appropriate, and providing information and opportunities for the Public to participate in activities that contribute to the achievement of the objectives of this Agreement." The Great Lakes Restoration Initiative (GLRI) Action Plan II lists a measure of progress in its "Foundations for Future Restoration Actions" focus, which is the "number of people educated on the Great Lakes ecosystem through GLRI-funded place-based experiential learning." Shipboard programs through the Grand Valley State University Annis Water Resources Institute (AWRI) and Michigan Sea Grant's Great Lakes Education Program (GLEP) provide onboard experiences for a variety of audiences (K-12, educators, general public). The two organizations have worked together on their GLRI-funded projects, and both programs advance the current GLWQA and GLRI priorities. The approaches of these two organizations have similarities and differences but they both foster Great Lakes literacy, which is an important element of effective public engagement. *Keywords: Public participation, Public education, Environmental education.*

VALIPOUR, R.[1], BOEGMAN, L.[2], BOUFFARD, D.[3], and YERUBANDI, R.[1], [1]Environment and Climate Change Canada, Water Science and Technology, Canada Centre for Inland Waters, Lakeshore Blvd, Burlington, ON, L7R 4A6, CANADA; [2]Queen's University, University Ave., Kingston, ON, K7L 3N6, CANADA; [3]École Polytechnique Fédérale de Lausanne, Lausanne, Lausanne, USA. **Sediment re-suspension by high-frequency linear internal waves in the Great Lakes.**

High-resolution field data, collected during April to October of 2008-09, were analyzed to investigate the quantitative contribution of sediment resuspension to high-turbidity events in central Lake Erie. Resuspension events were distinguished within high-turbidity events according to turbidity, fluorescence and acoustic backscatter timeseries, as well as satellite images. We observed 16 high-turbidity events, causing a total duration of ~20 days (out of 344 days) with elevated nearbed turbidity (> 10 NTU). Of these events, 64% were correlated with algal biomass, with the remaining 18%, 5%, and 4% being attributed to sediment resuspension by surface waves, storm-generated currents and enhanced nearbed turbulence induced by high-frequency internal waves, respectively. This is the first time that resuspension by enhanced nearbed turbulence from high-frequency linear internal wave degeneration has been observed in the Great Lakes. Resuspension was parameterized as a function of the instantaneous critical bottom velocity, bottom shear stress and the Shields parameter. From the in-situ measurements, we suggest an extended Shields diagram for silty bed material that can be used to predict resuspension in other aquatic systems with similar sediment composition (~20% cohesive sediment). *Keywords: Lake Erie, High-frequency linear internal waves, Sediment resuspension, Waves.*

VAN METER, K.J. and BASU, N.B., University of Waterloo, 200 University Ave. W., Waterloo, ON, N2L3G1, CANADA. **Nitrogen-Phosphorus Ratios: Hysteresis Effects and Long-Term Trajectories in the Grand River Watersh.**

Innovative conservation measures are increasingly being implemented in human-impacted watersheds to mitigate the impacts of intensive agriculture. Although such changes have the potential to improve water quality, we have insufficient knowledge regarding time scales of watershed response and ways in which changing management and land use impact the biogeochemical cycling of key nutrients. In the present work, we developed 100-year N and P mass balances for Ontario's Grand River Watershed and paired this data with N and P stream concentration data. Our results suggest that although both N and P surplus values have decreased by more than 50% in recent decades, the rates of decrease are not proportional, with N:P input ratios having doubled over this same period. In addition, our results show stream N:P ratios to be 5-6 times greater than N:P input ratios, suggesting higher retention rates and longer lag times for P. Significant lags were also identified between changes in N:P surplus ratios and subsequent changes in stream N:P ratios, thus indicating a strong hysteresis effect. Such lags in nutrient response and related changes in stream N:P ratios can have significant effects on microbial community structure and must be taken into account in attempts to reduce the incidence of eutrophication in Great Lakes watersheds. *Keywords: Nutrients, Water quality, Biogeochemistry.*

VANDER WOUDE, A.J.[1], MILLER, R.J.[2], JOHENGEN, T.H.[2], and RUBERG, S.A.[3], [1]Global Sciences and Technologies, Inc., 7855 Walker Drive, Suite 200, Greenbelt, MD, 20770, USA; [2]Cooperative Institute for Limnology and Ecosystems Research, University of Michigan, G110 Dana Building 440 Church Street, Ann Arbor, MI, 48109, USA; [3]NOAA GLERL, 4840 S. State Rd., Ann Arbor, MI, 48108, USA. **Variability in Lake Erie by Integrating Hyperspectral Imagery, AUV's and a Shipboard Underway System.**

During the 2016 field season, a variety of emerging technology platforms detected the harmful algal bloom (HAB) in the western basin of Lake Erie. In 2015 NOAA GLERL began airborne flights in the vicinity of water intakes with the Resonon hyperspectral camera. These efforts continued in 2016 along with two autonomous underwater vehicle (AUV) surveys and shipboard underway mapping. The mapping capabilities of each of these platforms created snapshots during the season to provide a synoptic overview of the moderate 2016 HAB event in preparation for an integrated effort in the future. During the August to October time frame, two AUV surveys, 18 hyperspectral camera overflights, and four underway mapping events occurred but were not simultaneous. The focus of this emerging technology presentation will be on the different spatial and temporal scales that each sensor observes, specifically chlorophyll and cyanobacteria, and how the strengths of each platform will be integrated during the 2017 field season to provide a three dimensional picture of surface and water column ecosystem structure. *Keywords: Lake Erie, Emerging technologies, Remote sensing, Hyperspectral imagery, Harmful algal blooms, Integration.*

VANDERPLOEG, H.A.[1], SARNELLE, O.[2], DENEF, V.J.[3], CARRICK, H.[4], ELGIN, A.K.[5], ROWE, M.D.[6], RUTHERFORD, E.S.[1], and POTHOVEN, S.A.[5], [1]NOAA Great Lakes Envrironmental Research Laboratory, Ann Arbor, MI, USA; [2]Michigan State University, East Lansing, MI, USA; [3]University of Michigan, Ann Arbor, MI, USA; [4]Central Michigan University, Mount Pleasant, MI, USA; [5]NOAA Great Lakes Environmental Research Laboratory, Muskegon, MI, USA; [6]CILER, University of Michigan, Ann Arbor, MI, USA. **Food-web impacts of Dreissena are Context-dependent: Mapping out a New Research Agenda.**

We have argued Dreissena feeding, nutrient excretion, and ecosystem engineering negatively impact food webs by promotion of harmful and nuisance algal blooms nearshore and starvation of the food web supporting offshore fisheries in the Great Lakes and inland lakes. However, impacts can vary greatly among lakes, seasons, and years. We review well-known and recently discovered mechanisms of Dreissena impacts and show how these same mechanisms lead to different results depending on stoichiometry, climate, physical habitat, and biota in the lake. Major weaknesses in understanding include incomplete knowledge in the following areas: fine-scale spatial interactions between Dreissena and other species, the role of physical variables in driving spatial structure, structure and function of classic and microbial food webs, and the role of stoichiometry in driving nutrient recycling by mussels. We draw on our observations from a number of Great Lakes, experiments in enclosures with different mussel and nutrient additions, and experiments exploring mussel-grazing impacts on the microbial food web. We outline frontier research areas and present a research agenda to promote better understanding and prediction of Dreissena impacts on food webs across systems. *Keywords: Biogeochemistry, Ecosystems, Dreissena.*

VANMENSEL, D.A.[1], CHAGANTI, S.R.[1], DROPPO, I.G.[2], and WEISENER, C.G.[1], [1]University of Windsor, 401 Sunset Ave, Windsor, ON, CANADA; [2]Environment and Climate Change Canada, Burlington, ON, CANADA. **Great Lakes Recreational Water Security - Human Pathogens and Sediment Dynamics.**

Microbial contamination and its impacts on beach closures and access to clean water within the Great Lakes is of great concern for public health and regional economic success. Over the last decade increasing frequency of pathogen outbreaks leading to beach closures have increased substantially compared to historic trends. There is still much debate regarding pathogen source (e.g. animal or human) and possible contributing vectors (e.g. sediment resuspension or water transport) for microbes impacting beaches. Conventional testing is generic and relies on *E coli* plate-cultures from water samples yielding results in 3-4 days. Intensive sampling started in 2016 was initiated to characterize bi-diurnal to bi-weekly biogeochemical fluctuations at beaches within the Lake Huron-Erie corridor. It is hypothesized that physico-chemical attributes of sediment influence pathogen quantity and microbial functionality. Attention is directed at microbial activity (i.e. type and source) at the sediment-water interface with correlations between community structure, water chemistry and sediment geomorphology. Microbial taxonomic and transcriptomic approaches will be applied. Results discussed will link geospatial influences such as those from terrestrial inputs (urban and agricultural sources) on the near shore sediment microbial community.
Keywords: Biogeochemistry, Sediment transport.

VASQUEZ, A.A., BURRIS, T., QAZAZI, M., and RAM, J.L., Department of Physiology, Wayne State University, 6132 Scott Hall, Detroit, MI, 48201, USA. **Molecular gut contents of water mites from Belle Isle's Blue Heron Lagoon, Detroit, Michigan.**

Water mites are predatory arachnids that inhabit aquatic habitats and are found worldwide. Water mites are one of the most biologically diverse microinvertebrates but according to leading acarologists only about half have been properly described in North America. In this study we have looked at the populations of water mites found in Blue Heron Lagoon, a lagoon of Belle Isle, Detroit, MI that was recently connected to Lake St. Clair by an EPA-funded habitat restoration project. Our preliminary studies revealed the presence of at least 15 genera of water mites with potentially several species represented at each genus by our molecular COI barcode studies. Use of an 18S chironomid family-specific primer revealed that at least two genera were feeding on chironomids from as early as June to as late as October. Additionally, molecular gut content analysis revealed previously unknown evidence that water mite diets in the field includes the consumption of chironomids by Arrenurus sp. deuteronymphs which are not known to feed on Dipteran larvae as adults. These preliminary data have led to a greater understanding of the dietary

habits of water mites. We are currently designing and testing other primers to establish baseline data that can be used for next generation sequencing of water mite molecular gut contents. *Keywords: Lake St. Clair, COI barcode, Biodiversity, Water mite and chironomid, Benthos, Belle Isle.*

VELIZ, M.[1] and FLEISCHHAUER, S.E.[2], [1]Ausable Bayfield Conservation Authority, 71108 Morrison Line, RR3, Exeter, ON, N0M 1S5, CANADA; [2]Maitland Valley Conservation Authority, 1093 Marietta Street, Box 127, Wroxeter, ON, N0G 2X0, CANADA. **From big to little watersheds: The use of water and sediment control basins to improve water quality.**

Rural non-point sources of nutrients (particularly phosphorus), sediment and bacteria can limit both the human uses and the ecological integrity of the near shore area of Lake Huron. To address the concerns, local communities have completed watershed plans and the implementation of agricultural best management practices (BMPs) in two shoreline watersheds in Huron County, Ontario. Between 2012 and 2015, a single water and sediment control basin (WASCoB) reduced peak flows during 97% of the runoff events measured. A watershed hydrologic model (SWAT) estimated that this WASCoB resulted in a reduction of phosphorus at the downstream outlet. Other land management practices, such as cover crops, have been difficult to measure at the edge-of-field scale and the use of the WASCoBs has helped to evaluate this practice. Furthermore, the recognition of WASCoBs as municipal infrastructure has provided an important opportunity for drainage proponents, farmers and conservation specialists to work together. *Keywords: Lake Huron, Stormwater, Nutrients, Rural, Monitoring.*

VERHAMME, E.M., RUCINSKI, D.R., BRATTON, J., SCHLEA, D.A., DEPINTO, J.V., and REDDER, T.M., LimnoTech, 501 Avis Dr, Ann Arbor, MI, 48108, USA. **Towards Operational Modeling of Great Lake Embayments: A2EM.**

Over the last five years LimnoTech has worked to develop the and apply the Advanced Aquatic Ecosystem Model (A2EM) to all of the major embayments on the Great Lakes including Saginaw Bay, Green Bay, and Western Lake Erie. The model framework serves as a state of the art ecosystem model that simulates hydrodynamics, temperature, wind-waves, sediment transport, nutrients, zooplankton, up to five algal classes including cyanobacteria, two filter feeders (Dreissenids), and benthic algae (Cladophora). The model is a powerful data integration and interpretation tool and can help managers and scientists isolate specific loading sources and identify key nutrient cycling pathways. The model has proven to be a valuable tool for managers and scientists. LimnoTech is working towards the development of the operational running of these models. When the models are updated on a

periodic basis the model can help to monitor lake responses to watershed nutrient reduction efforts and test new scientific hypothesis in near real-time or on a weekly, monthly, or annual basis. Operational ecosystem models, such as this one, complement existing monitoring programs very well and help to reduce uncertainty for managers that must make decisions regarding ecosystem responses to specific and often costly actions.
Keywords: Modeling, Hypoxia, Harmful algal blooms.

VINCENT, M.T., BREDEN, T.O., and BENCE, J.R., Quantitative Fisheries Center, 375 Wilson Rd., UPLA Room 101, East Lansing, MI, 48824, USA. **Analysis of a Four Region Tag-Integrated Catch-at-Age Model that estimates Natural Mortality.**

The influence of model complexity on Integrated Tagging and Catch-at-Age ANalysis (ITCAAN) parameter estimation is poorly understood for populations exhibiting natal homing. We used simulations to investigate the bias and precision of ITCAAN model estimates under varying levels of movement, degree of similarity in population productivities, data quality, and whether natural mortality and/or reporting rates were fixed at actual values, estimated, or misspecified. The operating model simulated the dynamics of four populations with natal homing that intermixed during periods of harvest based on parameters from Lake Erie walleye (*Sander vitreus*). Our results suggest that when high quality tagging data are available, ITCAAN models are able to simultaneously estimate movement rates, natural mortality and tag reporting rates. However, the accuracy and precision of model estimates generally decreased with greater model complexity and fewer tags released. ITCAAN models may have difficulty estimating individual population abundances under certain movement rates when population productivities are vastly different. ITCAAN models that estimate natural mortality and reporting rates may perform best with similar sized populations and when data are available to assist the estimation of reporting rates (e.g., High value tag releases). *Keywords: Spatial analysis, Fish tagging, Mathematical models.*

VOGIAZI, V., ZHANG, W., and DIONYSIOU, D.D., University of Cincinnati, Cincinnati, OH, 45221, USA. **Graphene electrodes and functionalization processes for cyanotoxins detection.**

Cyanotoxins originated from cyanobacteria are global and emerging contaminants. Recently, algae blooms have affected drinking water treatment plants in the city of Toledo in USA. Similar threatening incidents forced the U.S. Environmental Protection Agency (USEPA) to release a ten-day drinking water health advisory for cyanotoxins. In June 2015, USEPA advised very low concentrations for kids' consumption that may reach the 0.3 μg/L for microcystin-LR. The need of a field-portable, highly selective monitoring tool capable of measure the lowest possible cyanotoxins' concentration in drinking water sources and reservoirs is of high priority. Our team utilizes attractive carbon-based nanomaterials to demonstrate nanostructured microelectrodes for detecting microcystins in sources of drinking water. In this study, electrochemical nano-biosensors based on graphene were functionalized and characterized. Cyclic Voltammetry (CV) was used to explore the interfacial phenomena of the nano-biosensors. Using Ferro cyanide redox chemistry before and after functionalization on the electrodes confirmed surface modification. Potentiodynamic electrochemical measurements of graphene biosensors showed promising responses to microcystin-LR detection. *Keywords: Toxic substances, Algae, Monitoring.*

VOGLESONG, A.R., Michigan Sea Grant - International Joint Commission Fellow, 100 Ouellette Ave - 8th Floor, Windsor, ON, N9A 6T3, CANADA. **From Message to Method: What Data Does Your #SciComm Need?**

"Know Your Audience" is an oft-cited mantra of science communications, but data analysis is critical to inform the "who, what, where, when and why" of your message on social media. The criteria and context of Great Lakes science communicators' messages must be identified to select the appropriate analytic tools. The objective of this talk is to give an overview of analytic tools and how to use them. Drawing upon examples of data analyzed from the International Joint Commission's Great Lakes social media and other science communication mediums, methods are described for utilizing analytics to evaluate and modify communication strategies. Choosing the appropriate analytic tools can help researchers to maximize their #scicomm impact and minimize wasted effort on social media. Once researchers understand and are comfortable with the basics, more complicated analytic measures, including Social Network Analysis, can be used to fine-tune their campaigns. Results of this research discuss the fundamentals of selecting analytic tools that inform decisions about a social media campaign's targeted audience, platform selection, message selection, timing, and more. In conclusion, not all are useful, but specific analytics can help researchers set and meet their #scicomm goals. *Keywords: Great Lakes basin, Science communication, Social media.*

VOUK, I.[1], COUSINEAU, J.[1], JENKINSON, W.[2], PILECHI, A.[1], and BURCHER, R.S.[1], [1]National Research Council, 1200 Montreal Rd., Ottawa, ON, K1A 0R6, CANADA; [2]International Joint Commission, Canadian Section, 234 Laurier Ave. West, Ottawa, ON, K1P 6K6, CANADA. **Online and Interactive Visualization Tools to Communicate Science.**

The National Research Council (NRC) has developed online and interactive visualization tools for disseminating scientific and technical information to all stakeholders, including laypersons. When a technical study is completed the work and the outputs are often described in a detailed report using high-level scientific language and visuals overwhelming for a layperson. Moreover, numerical simulations of dynamic processes often cannot be effectively communicated within a conventional report. In response, NRC has been developing interactive visualization tools to help communicate key information to all stakeholders. The tools are simple to use, and are developed using Python, HTML and Java Script, all software that is readily available without cost. Examples will be provided of tools developed to present hydrodynamic modelling results describing the complex relationship between hydroelectric dam control, water levels and flood risk. The new tools help raise awareness of the efforts and contributions made by authorities, increase the community's knowledge and, can help build consensus and support for proposed mitigation measures. By blending ingenuity and programming skill, innovative visualization tools can be created to improve the communication of complicated science and engineering results and enhance public outreach. *Keywords: Public education, Visualization tools, Hydrodynamic model, Outreach.*

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WAGNER, A.C. and JOHNSON, E.M., U.S. Army Corps of Engineers - Detroit District, 477 Michigan Ave, Detroit, MI, 48226, USA. **Engineering-Design Framework for the Implementation of Ecosystem Restoration Projects.**

The States of Minnesota and Wisconsin are coordinating remediation and restoration projects within the St.Louis River Area of Concern by implementing over 60 independent actions described in an approved Remedial Action Plan (RAP). Aquatic habitat restoration is fundamental to a successful RAP. Restoration activities are focused on removing the following Beneficial Use Impairments: Loss of Fish and Wildlife Habitat and Degradation of Benthos. The RAP goal is to create optimal water depth and flow conditions needed to establish submergent, floating leaf, and emergent aquatic vegetative assemblages that support a healthy benthic community and a robust fishery. For ecosystem restoration projects it is imperative to clearly define the impairments, the desired outcomes, and methods to measure impairments and benefits. Creating a design framework requires the input of stakeholders, designers, subject matter experts and regulators to ensure a sustainable, repeatable, and constructible project. Ecosystem restoration design requires ecological, civil, hydrodynamic, and geotech analysis performed with numerical modeling and supported with site specific variables. This presentation will encompass the design framework developed, engineering and analysis, and applicability to future aquatic restoration projects in the Great Lakes Region. *Keywords: Coastal ecosystems, St. Louis River AOC, Decision making, Beneficial use impairments, Mathematical models.*

WAISANEN, E.[1], KEELEY, K.[1], KURTZ, E.[1], LI, L.[1], XIN, Y.[1], ZHANG, F.[1], PEARSALL, D.[2], and CURRIE, W.S.[1], [1]School of Natural Resources and Environment, University of Michigan, Ann Arbor, MI, USA; [2]The Nature Conservancy, Lansing, MI, USA. **Supporting Conservation and Decision-Making in the Northwoods: Mapping Values, Services, and Threats.**

The forests of northern Michigan, Wisconsin, and Minnesota provide numerous services, such as filtering of water for the Great Lakes. Planning and management of this ecosystem involves various entities in multiple jurisdictions. These entities lack a common framework for regional planning and coordinated decision-making. In this pilot study, we explored "Story Maps", an interactive web application from ESRI, as a tool for effective communication and collective decision-making by framing spatial data with narrative text and multimedia. Our "Story Map" communicate how people value certain aspects of the Northwoods and threats to these values, focusing on three values: the role of forests in protecting water quality, forest products sector jobs, and nonconsumptive outdoor recreation. Preliminary maps illustrate the water quality conditions and threats to water quality within watersheds, including changes in land use and land cover, sedimentation and erosion. We also learned that values have different meanings to different stakeholders. Finding consistent, region-wide spatial data to map those values is also daunting. Our "Story Map" will be used by Northwoods managers and decision-makers to support improved regional decision-making and will serve as a foundation for more sophisticated decision-support tools. *Keywords: Data acquisition, Decision making, GIS.*

WALLACE, H.A., JI, T., and ROBINSON, C., Civil and Environmental Engineering, University of Western Ontario, Richmond Street, London, ON, N6A 3K7, CANADA. **Application of Rn-222 for Identification and Quantification of Groundwater Discharge to Lake Simcoe.**

Groundwater discharge may be an important pathway for delivering pollutants to lakes, but due to high variability this pathway is not well understood. In order to understand its effect on lake water quality trends, the spatial distribution and volume of discharge must be quantified. The first objective of this study was to evaluate the use of the natural radon isotope tracer (Rn-222) for identifying areas of high groundwater discharge and quantifying this discharge to large lakes. Regional 222-Rn surveys were conducted in Lake Simcoe, a lake in Ontario. Spatial variability of Rn-222 in lake water concentrations allowed groundwater discharge hotspots to be identified, and mass balance calculations were used to determine the volume of discharge in these areas. Regional hydrogeological features were linked to groundwater discharge providing broadly applicable understanding of observed spatial distribution. The second objective of the study was to investigate uncertainties associated

with using 222-Rn as a tracer; influence of environmental factors on lake water concentrations, and aquifer heterogeneity on groundwater concentrations. The findings of this study provide a more reliable method for evaluating groundwater discharge to large lakes, to focus efforts aimed at managing non-point pollution sources like groundwater discharge. *Keywords: Environmental Tracer, Regional analysis, Groundwater, Hydrologic budget, Lake Simcoe, Hydrogeology.*

WANG, J.[1], KESSLER, J.A.[2], HU, H.[2], FUJISAKI-MANOME, A.[2], CLITES, A.[1], LOFGREN, B.M.[1], and CHU, P.[1], [1]NOAA Great Lakes Environmental Research Lab, 4840 S State Road, Ann Arbor, MI, 48108, USA; [2]University of Michigan, Coperative Institute for Limnology and Ecosystem Research, 4840 S State Road, Ann Arbor, MI, 48108, USA. **Seasonal forecast of Great Lakes ice cover using multi-variable regression and FVCOM+ice models.**

In this study, temporal variability of ice cover in the Great Lakes is investigated using historical satellite measurements undated from 1973 to 2016. It was found that 1) Great Lakes ice cover has a linear relationship with Atlantic Multidecadal Oscillation (AMO), similar to the relationship of lake ice cover with the North Atlantic Oscillation (NAO), and 2) a weak quadratic relation with the Pacific Decadal Oscillation (PDO), similar to the relationship of lake ice cover with the Nino3.4. Based on these dynamic relationships, the original multiple variable regression model established using the indices of NAO and Nino3.4 is updated by adding both AMO and PDO, as well their competing mechanism. With the AMO and PDO added, the correlation between the model and observation increases to 0.69, compared to 0.56 using NAO and Nino3.4 only. In 2016/17 ice season, we also used the FVCOM+ice model to project seasonal ice cover using the NCEP/CFS 9-month projected 6-hourly atmosphere forcing from November 1, 2016 to July 31, 2017. The projected ice cover in Lakes Michigan, Erie, and Ontario is consistent with that by the regression model, while there are large discrepancy between these two models in Lakes Huron and Superior. *Keywords: Climatology, Ice, Modeling.*

WANG, Y.C.[1], MUENICH, R.L.[1], KALCIC, M.M.[2], and SCAVIA, D.[1], [1]Graham Sustainability Institute, University of Michigan, 625 E. Liberty St., Suite 300, Ann Arbor, MI, 48104, USA; [2]Department of Food, Agricultural and Biological Engineering, Ohio State University, 590 Woody Hayes Drive, Columbus, OH, 43210, USA. **Predicting CSO Discharges to Improve Watershed Modeling and Nutrient Load Estimates.**

Combined sewer overflows (CSO) occur when a wastewater treatment system is overloaded with inflow and releases sewage directly into waterways, potentially impairing water quality. However, few watershed modeling applications have focused on estimating the impact of CSO on water quality. Our objective is to develop an approach to predict the flow and loading from CSO based on site and climatic data to improve watershed modeling. We analyzed data from 25 CSO facilities located in the Maumee River Watershed with regression analyses on monthly CSO volume and total precipitation from the nearest weather station. Three facilities (Fort Wayne, Lima, and Toledo Wastewater Treatment Plants) together generated more than 90% of the total CSO volume. Monthly precipitation was a strong predictor for monthly CSO volume for the three largest dischargers. Estimated nutrient loads were then coupled with the Maumee River SWAT model to account for the nutrient contribution of CSO events in the historical time period. This approach has the potential to further predict future CSO impacts under climate change, thus improving future scenario analyses. *Keywords: Lake Erie, Combined Sewer Overflows, Pollution load, Water quality.*

WARANIAK, J.M.[1], BAKER, E.A.[2], and SCRIBNER, K.T.[1], [1]Dept. Fisheries and Wildlife, Michigan State University, East Lansing, MI, USA; [2]Michigan Dept. of Natural Resources, Marquette, MI, USA. **Genetic diet analysis detects predation of larval lake sturgeon (*Acipenser fulvescens*).**

Predation affects recruitment during early life stages of many fish. Genetic tools can improve predation studies on larval fish because prey DNA is detectable in predator gastrointestinal (GI) tracts much longer than physical remains can be identified. Potential fish predators (N=1140) of lake sturgeon (*Acipenser fulvescens*) larvae were collected in four 500-m transects dominated by sand (N=2) and gravel (N=2) substrates over 17 days during 2015 and 2016. Sampling with D-frame drift nets was conducted to estimate the nightly abundance of larval lake sturgeon and other co-distributed prey. DNA was extracted from GI tracts of potential predator fish, and sturgeon-specific PCR primers amplified part of the cytochrome oxidase I region of mitochondrial DNA to detect the presence of lake sturgeon DNA. Molecular analysis identified lake sturgeon DNA in a total of 73 samples (6.4%), compared to one sample (0.09%) detected by morphological analysis. Binomial logistic regression modeled the relationship between the frequency of occurrence of lake sturgeon predation with environmental variables (e.g. larval lake sturgeon abundance, cloud cover). Applying molecular tools to this complex ecological system can identify important factors affecting recruitment and inform what management efforts could improve survival of larval sturgeon. *Keywords: Genetics, Predation, Fish diets.*

WARREN, C.J.[1], LEWIS, J.W.[2], FRY, L.M.[1], and PERKINS, J.K.[1], [1]U.S. Army Corps of Engineers - Detroit District, Detroit, MI, USA; [2]U.S. Army Corps of Engineers - ERDC, Vicksburg, MS, USA. **Investigation of Simulated and Observed SWE for Water Level Forecasting of the Great Lakes.**

The U.S Army Corps of Engineers uses a suite of models to generate forecasted net basin supplies (NBS) for the Laurentian Great Lakes. Among these is the Large Basin Runoff Model (LBRM), a physically based lumped parameter model that incorporates snow accumulation and melting processes and comprises the runoff component of NOAA's Great Lakes Advanced Hydrologic Prediction System. Preliminary investigations have demonstrated the utility of using LBRM-modeled snow water equivalent (SWE) (1948-2011) to determine the historical proportion of runoff represented by snowmelt and use that ratio to adjust forecasted net basin supplies using near real-time SWE estimates. This presentation describes work to extend this NBS adjustment method to all 5 lake basins and compare LBRM-simulated SWE to estimates obtained from data assimilation products for the Lake Superior and Lake Erie basins to assess the suitability of modern SWE observations. *Keywords: Comparison studies, Snowmelt, Great Lakes basin, SWE, Modeling, Forecasting.*

WARREN, G.J.[1], LESHT, B.M.[2], and BARBIERO, R.P.[3], [1]U.S. EPA, 77 W. Jackson Blvd., Chicago, IL, 60604, USA; [2]CSRA and Department of Earth and Environmental Sciences, University of Illinois at Chicago, 845 W. Taylor St., Chicago, IL, 60607, USA; [3]CSRA, 1359 W. Elmdale Ave., Suite 2, Chicago, IL, 60660, USA. **Are Inputs from Large Bays Important to Whole Lake Productivity?**

Large Great Lakes embayments receive significant nutrient loads, a portion of which mix into the main body of lakes. The flux of materials across bay mouths will have an impact on the productivity in the whole lake. As productivity in many offshore regions of the Great Lakes declines, these fluxes can be of increasing importance to whole lake productivity, in determining both the overall production of the lake as well as the spatial distribution of that production. The flux rates are, likely, weather dependent and can be influenced by high bay loads from rain events and high, lakeward, wind events, alone or in combination. We use chlorophyll measurements from satellite imagery to track movement of materials from Green Bay, Lake Michigan and Saginaw Bay, Lake Huron, into the lakes. We estimate the amount of production that can be attributed to loading of materials from the bays and investigate the spatial extent and timing of production. *Keywords: Productivity, Remote sensing, Water currents.*

WARRINER, T.R., SEMENIUK, C.D., PITCHER, T.E., and LOVE, O.P., 401 Sunset Ave, 401 Sunset Ave, Windsor, ON, N9B 3P4, CANADA. **Adaptive stress: maternal stress may optimize salmon offspring performance under climate change.**

Climate change is a significant driver of elevated water temperatures across the globe, altering temperature regimes which may result in large effects on aquatic life, particularly for fish whose early development is temperature-dependent such as salmon.

However, intergenerational effects such as maternal stress may dampen negative effects on offspring performance. Recent studies suggest that if offspring encounter the same stressful environment as their mother, a pre-natal stress signal may enable offspring to prepare for the same stressed environment (environmental match). But, if her offspring encounter a different environment, the maternal stress signal may be detrimental (mismatch). To examine whether a maternal stress signal may prepare offspring for a stressful environment under the climate change, we exposed Lake Ontario Chinook salmon (*Oncorhynchus tshawytscha*) eggs to 0 or 1000ng/mL cortisol stress signal and incubated them at temperatures indicative of current and future climate conditions (3°C higher). We tracked offspring survival and growth, and will examine physiological and behavioural performances under these two temperature regimes. This study tests the environmental match theory using salmon, an ecologically and commercially important fish with the environmentally relevant context of climate change. *Keywords: Salmon, Climate change, Credit River.*

WATERS, S.A.[1], SCHROEDER, B.C.[2], D'AUGUSTINO, T.M.[2], and GASS, M.J.[4], [1]Thunder Bay National Marine Sanctuary, 500 W. Fletcher Street, Alpena, MI, 49707, USA; [2]Sea Grant, Michigan State University Extension, 603 South 11th Ave, Alpena, MI, 49707, USA; [3]Michigan State University Extension, 320 S. State Street, Harrisville, MI, 48740, USA; [4]Northeast Michigan Great Lakes Stewardship Initiative, 500 W. Fletcher St., Alpena, MI, 49707, USA. **Place-based Stewardship Education and Citizen Science: A Powerful Partnership in Northeast Michigan.**

Place-based stewardship education (PBSE) is a proven method of bringing students closer to their communities and developing knowledgeable and active stewards of the environment. Citizen science enlists members of the public in the collection of valuable scientific data. Combining the two, the Northeast Michigan Great Lakes Stewardship Initiative (NEMIGLSI) sponsors an award-winning suite of programs that promotes PBSE experiences for K-12 students. Alongside Great Lakes scientists and natural resource professionals, youth are helping to conserve Lake Huron's biodiversity, map threatened and endangered species habitat, restore native fisheries, monitor vernal pool wetlands, preserve our maritime heritage, and investigate marine debris. During the 2015-2016 school year, the NEMIGLSI supported 94 educators in 32 schools across eight northern Lake Huron counties, involving more than 4,100 youth (approximately 20% of the region's total student population) in stewardship projects. The NEMIGLSI partnership is one of nine regional hubs of the Great Lakes Stewardship Initiative (GLSI), a statewide effort to develop knowledgeable, active stewards of the Great Lakes. Newly available tools such as the GLSI's *Guiding Principles for Exemplary Place-based Stewardship Education* will be shared during the presentation. *Keywords: Education, Place-based, Citizen science, Stewardship, Lake Huron.*

WATKINS, J.M.[1], BARBIERO, R.P.[2], BOWEN, K.L.[3], CURRIE, W.J.S.[3], and RUDSTAM, L.G.[1], [1]Cornell University, 900 Shackelton Pt Rd, Bridgeport, NY, 13030, USA; [2]CSC, 1359 W Elmdale, Suite 2, Chicago, IL, 60660, USA; [3]Department of Fisheries and Oceans, 867 Lakeshore Rd, Burlington, ON, L7R 4A6, CANADA. **Reevaluating Zooplankton Based Ecosystem Indicators Across the Great Lakes.**

Common ecological indicators based on zooplankton include total biomass, community diversity, number of exotic species, mean body size, species transitions, and ratios of different groups (i.e. calanoids and cyclopoids+cladocerans). These have been used in the past to infer both bottom up (chlorophyll and trophic state) and top down (fish predation) forcing as well as to establish general integrity or degradation. However, many of the traditional indicators have become less effective as new species introductions, continued oligotrophication, and other large scale ecological shifts have occurred. Placing a status (good or bad) on these indicators has also proven increasingly complex due to different priorities of basin stakeholders. We use the GLNPO zooplankton data time series and other data sources to evaluate several traditional zooplankton-based indicators for all five Great Lakes. We develop a set of new indicators that provide an improved ability to diagnose the Great Lakes. *Keywords: Great Lakes basin, Indicators, Zooplankton.*

WEGHER, M.E. and RENNIE, M.D., Lakehead University, 955 Oliver Rd, Thunder Bay, ON, CANADA. **Understanding Spatial Variation in Food Web Connectivity Within Lake Superior.**

Lake Superior, like all the Great Lakes, hosts a broad diversity of habitats occupied by similar fish species. However, the degree to which this variation in habitat type ultimately influences the pathways and rates of energy flow are not well understood. Unlike other Great Lakes, Dreissenid mussels have not yet established significantly. Studies have shown dreissenid colonization can alter offshore food webs by redirecting energy to nearshore areas they inhabit. The degree of natural variation in nearshore/offshore contributions in the Great Lakes against which to assess dreissenid-induced shifts is not known. This study assesses spatial variation in energy sources across four regions of Lake Superior collected during summer of 2016; Nipigon Bay, the western side of the Keweenaw Peninsula, Whitefish Bay, and the Western Arm. We analyzed stable isotopes of rainbow smelt, longnose sucker and sculpin species, using benthic invertebrates and zooplankton as nearshore/benthic and offshore/pelagic baselines respectively. The degree of nearshore versus offshore contributions among sites will be evaluated. This study will provide an estimate of natural variation in nearshore-offshore connectivity among Lake Superior food webs against which to evaluate changes in the lower lakes due to driessenids.
Keywords: Dreissena, Stable isotopes, Lake Superior.

WEHRLY, K.[1], RISENG, C.[2], MCKENNA, J.[3], SPARKS-JACKSON, B.[2], MASON, L.[2], RUTHERFORD, E.[4], WANG, L.[5], and INFANTE, D.[6], [1]Michigan Department of Natural Resources, Ann Arbor, MI, 48109, USA; [2]University of Michigan, Ann Arbor, MI, 48109, USA; [3]USGS Great Lakes Science Center, Cortland, NY, 13045, USA; [4]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, 48108, USA; [5]International Joint Commission, Windsor, ON, N9A 6T3, USA; [6]Michigan State University, East Lansing, MI, 48824, USA. **A Condition Assessment of Multistressors on Nearshore Fish Habitat in the Great Lakes Basin.**

We used the Great Lakes Aquatic Habitat Framework (GLAHF), spatial habitat data harmonized across US and Canada, and published human disturbance indices to assess the condition of fish habitat for all nearshore areas (3-30m) of the Great Lakes. Our approach involved developing models linking fish abundance to spatial habitat variables, predicting and mapping suitable fish habitats for each species, overlaying human disturbance maps, and assessing habitat potential and condition for each species and lake. Using USGS bottom trawl data, we developed neural network models for 53 fish species that accurately explained variation in observed fish abundance data. Important habitat variables in these models included descriptors of water thermal regime, depth, mechanical energy, and distance to shoreline habitat features. Overlaying human disturbance indices revealed considerable variability in fish habitat condition within each lake and across the Great Lakes basin. Our assessment represents the first basin wide effort to quantify and map fish habitat suitability and condition, and can be used to prioritize nearshore areas of the Great Lakes for funding & fish habitat conservation. *Keywords: Risk assessment, Habitats, GIS.*

WEHRLY, K.E., Michigan Department of Natural Resources, Ann Arbor, MI, 48109, USA. **Jim Diana's Contribution to the Michigan Department of Natural Resources.**

Throughout his career, Jim has actively worked with the Michigan Department of Natural Resources Fisheries Division. He has influenced the agency and fisheries management through mentoring of students, collaborative research, serving on committees, and other service. Many of Jim's students have gone on to work for the Michigan DNR and have made significant contributions themselves by serving in top leadership positions. Over the years, Jim has worked closely with the Institute for Fisheries Research, a cooperative between the Michigan DNR and the University of Michigan. Jim has been an outspoken supporter of the Institute and has worked tirelessly to promote and ensure its legacy. In this talk, I reflect on the influential role Jim Diana has had on the agency responsible for fisheries management in the State of Michigan. *Keywords: Fish management, Institute for Fisheries Research, Education.*

WEI, B. and BOYER, G.L., SUNY-ESF, 1 Forestry Drive, Syracuse, NY, 13210, USA. **Phototransformation of Cyanobacterial Hepatotoxin Microcystin-LR by Ultraviolet Irradiation.**

Toxic cyanobacterial blooms are a growing environmental and human health concern. The most commonly occurring toxins produced by cyanobacteria are microcystins (MCs). This toxin affects the liver by forming a permanent covalent linkage with the enzyme protein phosphatase. Among the microcystins, microcystin-LR (MC-LR) is found to be one of the most abundant and the most toxic. It is thus necessary to develop effective treatment methods to remove microcystin-LR from contaminated water. Photodegradation is a very important way to remove contaminants in natural water system. Since the defined absorption band of MC-LR in the UV range has a maximum at 238 nm, we might expect the removal of MC-LR under Xenon light. To prove our hypothesis, we use 800MHz ^{1}H NMR to identify the structure of standard MC-LR and the product after UV irradiation. The results shows that when microcystin-LR was exposed to UV, two new compounds were identified as [4(E), 6(Z)-Adda]- and [4(Z), 6(E)-Adda] microcystin-LR and they were produced in equal amount. *Keywords: Phototransformation, Toxic substances, MC-LR, Ultraviolet radiation.*

WEI, L., Nanjing Institute of Geography and Limnology, Chinese Academy of Science, 73 East Beijing Road, Nanjing, JS, 210008, CHINA. **Dynamics of spatiotemporal heterogeneity of cyanobacterial bloom in large eutrophic Lake Taihu.**

Cyanobacterial blooms caused by eutrophication are recognized as highly heterogeneous spatiotemporally in Lake Taihu, China. In this study, it is assumed that highly spatiotemporal heterogeneity and plaque-like patterns of algal blooms are determined by divergence/convergence processes of fluid. To prove this assumption, three episodes of the dominant spatial patterns of hourly simulated divergence fields in Lake Taihu in July of 2012 were analyzed using a hydrodynamic numerical model combined with the Empirical Orthogonal Function (EOF) method. The results showed that, on days that blooms occurred, the first two EOF modes explained 89.37% of the variability and the dominant spatial patterns of stronger convergence zones are in agreement with the regions of bloom occurrence and accumulation. When no blooms occurred, the first EOF mode explained 72.54% of the variability and the divergence zones were dominant in the lake. Both the simulated hourly average divergence field and the first EOF mode in the time interval in which blooms occurred further confirm that blooms accumulate in the current convergent zones. These findings explain the dynamic mechanism of occurrence of plaque-like cyanobacterial blooms and will facilitate short-term blooms forecasting for securing drinking water supplies and managing risk. *Keywords: Waves, Modeling, Algae.*

WEIDEL, B.C.[1], WALSH, M.G.[1], CONNERTON, M.[2], LANTRY, B.F.[1], YUILLE, M.J.[3], and HOLDEN, J.P.[3], [1]USGS, Great Lakes Science Center, Oswego, NY, USA; [2]New York State Department of Environmental Conservation, Cape Vincent, NY, USA; [3]Ontario Ministry of Natural Resources and Forestry, Picton, ON, CANADA. **Round Goby's influence on Lake Ontario fish community and food-web dynamics.**

As the dominant Lake Ontario benthic prey fish, Round Goby influence fish community and food-web dynamics. Goby abundance cycles on a 3-4 year period with current lake-wide densities of ~600 fish/ha and maximum densities of 1500 fish/ha in 2012. Since 2004, Round Goby have dominated the benthic fish community, while native, nearshore species, (e.g. Trout-perch, Spottail Shiner, Johnny Darter) have declined. In non-embayment areas, Round Goby undergo a seasonal depth change. Mean depth of capture is <20m in June but >100m in winter. Since Round Goby > 60mm primarily feed on dreissenid mussels 8-13mm, Round Goby depth preference may be related to the availability of suitable-sized mussels. Mixed-effects models suggest fall, offshore depth changes are slower (0.5 m/day) than spring depth changes (-20 m/day). Inshore Round Goby movement may have implications for spring, nearshore nutrient dynamics. The relative importance of Round Goby to piscivores is related to piscivores water column position, with greater importance for bottom-oriented species and less importance for Pacific salmonids. Round Goby have changed the Lake Ontario benthic fish community composition, however overall biomass density has not changed. Round Goby are more effective than native species connecting dreissenid mussel energy to piscivores. *Keywords: Lake Ontario, Round goby, Dreissena.*

WEINKE, A.D., KNAPP, K.L., and BIDDANDA, B.A., Annis Water Resources Institute - Grand Valley State University, 740 W. Shoreline Dr., Muskegon, MI, 49441, USA. **Time-series and discrete data reveal dynamics and consequences of hypoxia in Muskegon Lake, Michigan.**

As the number of known hypoxic zones expands around the world, we are concerned with its ecosystem level consequences. In 2015, we combined the use of an automated high-frequency monitoring buoy on Muskegon Lake, Michigan, with a lake-wide sampling survey to evaluate the occurrence and influence of episodic wind events, spatial and temporal extent of hypoxia, and ecological factors such as nutrients, phytoplankton, and fish. We did this with the goal of finding out when and where hypoxia occurs in the lake, what effects does it have, and what effect episodic wind events may have on these two factors. We found that episodic wind events are quite frequent on Muskegon Lake during the summer-fall hypoxic period. While most events lack the power to completely mix the lake, few events have the ability to at least significantly cut into the hypoxic bottom waters.

These major events may mix high concentrations of internally loaded phosphorus from the bottom waters into the surface waters. We observed a large bloom of Microcystis following one such mixing event, that was sustained for several weeks by other mixing events during the bloom. Overall this study illustrates the usefulness of combining high-frequency remote monitoring data with discrete measurements in ecosystem studies. *Keywords: Microcystis, Episodic Wind-Events, Monitoring, Hypoxia, Buoys, Time-Series Data.*

WELLEN, C.C.[1] and MOHAMED, M.N.[2], [1]University of Windsor, Windsor, ON, CANADA; [2]Ontario Ministry of the Environment and Climate Change, Toronto, ON, CANADA. **Advancing Policy-Science Dialog Using models: An Example of Watershed Modeling in Ontario.**

There is a pressing need to understand how land use and management interact with physiography (e.g., climate, soils, geology) to determine losses of water quality constituents to streams and ultimately, receiving water bodies. This stems, in part, from a need to craft policy instruments intended to reduce losses of these substances from landscapes. To create a dialog between science and policy, mathematical models are often used as the 'boundary object', where policy alternatives are input and their outcomes are projected. Using the example of an agricultural watershed monitoring project and associated mathematical modelling effort in Ontario, Canada, this talk will discuss how mathematical models of watershed nutrient export are being used to develop a dialog between science and policy. Specifically, we will focus on the importance of policymaker and stakeholder engagement in model development at an early stage and the difficult but necessary process of securing stakeholder participation. We also discuss the tension inherent in scenario development when such stakeholders are involved. While stakeholders often desire scenarios that are feasible, desired outcomes may require scenarios that are not realistic. We conclude with a set of recommendations for model development to ensure engagement with management. *Keywords: Modeling, Policy making, Watersheds.*

WELLER, J.D. and CHOW-FRASER, P., McMaster University, 1280 Main Street West, Hamilton, ON, L8S 4K1, CANADA. **Hydrogeomorphic Modeling of Coastal Marsh Extent in Georgian Bay, Lake Huron.**

Coastal marshes in Georgian Bay, Lake Huron are among the most pristine habitats in the Laurentian Great Lakes. Anthropogenic influences threaten to compromise the quality of the coastal marshes but environmental conditions, most notably water levels, currently appear to be the primary determinant of the status of wetland habitat in Georgian Bay. Given the value of coastal marsh habitat for Great Lakes fish and wildlife and the uncertainty of the impacts of climate change on future lake levels, managers must be able to predict how the availability of this habitat type will change under different water level scenarios. We used a digital elevation model (DEM) of Georgian Bay and an inventory of coastal marshes (McMaster Coastal Wetland Inventory; MCWI) to develop a predictive model of the extent of coastal marsh habitat. We used the DEM to derive parameters for relevant hydrogeomorphic features (e.g. depth, slope, wave exposure) of the MCWI marshes under low water conditions (176.13 m asl). We modeled the extent and distribution of coastal marshes in eastern and northern Georgian Bay under a range of lake elevations (174.0 to 177.0 m asl) to evaluate the effect of lake level on the availability of coastal marsh habitat. This model provides a valuable tool for evaluating the effect of water level on coastal marsh habitat. *Keywords: Coastal wetlands, Georgian Bay, Water level.*

WELLS, D.J.[1], PSAROUTHAKIS, Z.[1], RUTHERFORD, E.[2], CHIN, T.[1], VANDERPLOEG, H.A.[2], CAVALETTO, J.F.[2], and GLYSHAW, P.[1], [1]Cooperative Institute for Limnology and Ecosystems Research, 440 Church Street, Ann Arbor, MI, 48109, USA; [2]NOAA GLERL, 4840 S. State Rd., Ann Arbor, MI, 48108, USA. **Shock and Awe! Estimating Mysis Density and Catch Avoidance using the MOCNESS in SE Lake Michigan.**

Mysis diluviana is a key member of Great Lakes aquatic food webs and is important prey for pelagic planktivores. Mysis are visual predators of zooplankton, and migrate diurnally from the lake bottom into the water column. Mysis biomass estimates are highly variable but critical for food web models that inform salmonid stocking decisions. In 2016, we evaluated catch efficiency of Mysis in a Multiple Opening/Closing Net and Environmental Sensing System (MOCNESS) with LED strobe lighting that is used to sample plankton and fish larvae in marine waters. We sampled Mysis density at a mid-depth (45 m) station in June and July, and at an offshore (110m) station in September off Muskegon, MI. We made replicate tows in thermally stratified depth layers during day and night, and compared Mysis densities sampled with the LED strobe on vs strobe off. There were no significant differences in Mysis density among depths in samples with strobe on or off in any month. Mysis were concentrated in dense layers in the metalimnion at night, and were highest in the hypolimnion during day. We conclude that the strobe flash light had no effect on catch avoidance by Mysis. *Keywords: Mysis, Lake Michigan, MOCNESS.*

WELLS, M.G.[1], FLOOD, B.[1], VALIPOUR, R.[2], SEMCESEN, P.[2], and PARKER, S.[3], [1]University of Toronto Scarborough, 1265 military Trail, Toronto, ON, M1C1A4, CANADA; [2]Environment and Climate Change Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6, CANADA; [3]Parks Canada, 248 Big Tub Road, Tobermory, ON, N0H 2R0,

CANADA. **Investigating the water movements around a shallow shipwreck in Lake Huron.**

Big Tub Harbour in Fathom Five National Marine Park, Tobermory, Ontario is famous for its two shipwrecks; the Sweepstakes (1867-1885) and the City of Grand Rapids (1879-1907) and its clear waters, making it an ideal tourist destination to experience Canada's maritime history firsthand. Continued exposure to various natural and vessel derived currents has directly and indirectly affected the integrity of the wrecks and has resulted in management interventions including efforts to stabilize the Sweepstakes and control vessel activity. This presentation will investigate the various hydrodynamic processes present in Big Tub Harbour, Lake Huron, and their potential to impact the wreck including scouring around the Sweepstakes. In the Big Tub Harbour, wind-induced surface gravity waves, internal gravity waves, and anthropogenic factors can cause water velocities at the bed to increase above the shear velocity resulting in sediment resuspension and potentially sediment transport leading to scouring around underwater structures. In 2015, a project was jointly undertaken by Parks Canada, Environment Canada and the University of Toronto to quantify and differentiate natural versus man-made summer water movements in Big Tub Harbour. *Keywords: Water currents, Shipwrecks, Lake Huron.*

WEN, L.[1], LI, Z.[1], ZHAO, L.[1], KIRILLIN, G.[2], and MACINTYRE, S.[3], [1]Northwest Institute of Eco-Environment and Resources, Chinese Acedemy of Sciences, Donggan West Road 320#, Lanzhou, GS, 730000, CHINA; [2]Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Berlin, GERMANY; [3]University of California, Santa Barbara, Santa Barbara, USA. **Air-lake boundary layer and thermal condition in Tibetan lakes.**

The Tibetan Plateau (TP) is covered by thousands of lakes which affect the regional and global heat and mass budget with important implications for the current and future climate change. However, the heat and mass budget and thermal condition of TP lakes have not been studied a lot. We utilise the observation from Ngoring Lake, the largest lake in the Yellow River source region of TP, and a simplified lake scheme from the Community Land Model version 4.5 (SLCLM) to investigate the typical properties of the lake. The strong boundary layer instability during the entire open-water period is a distinguishing feature of the airlake exchange, similar to the situation over tropical and subtropical lakes, while contrasting to the generally stable atmospheric conditions commonly observed over ice-free temperate and boreal lakes from spring to summer.The cold air and strong radiation over TP have significant impacts on the air-lake boundary and thermal condition. *Keywords: Air-water interfaces, Modeling, Lake model.*

WESLEY, J.K., Michigan Department of Natural Resources, 621 N. 10th Street, Plainwell, MI, 49080, USA. **The Diana effect: how opportunity, networks, and research helped a graduate student and salmon.**

After several months of job and graduate project searching, the acceptance to the University of Michigan and project with Dr. Diana in 1994 was a blessing even for a student from Michigan State University. The maize and blue were distracting, but it was the perfect place for a student to advance his knowledge in fisheries and to absorb the knowledge from existing and historic biologists from the Institute of Fisheries Research. It was an incredible opportunity and experience that lead to age and growth research important to Chinook salmon management. Today, managers and anglers still struggle with the acceptance of balanced alewife and Chinook salmon abundance to maintain a popular sport fishery.
Keywords: Fish management, Salmon, Lake Michigan.

WHITACRE, S.D. and DAYTON, E.A., The Ohio State University School of Environment and Natural Resources, 2021 Coffey Rd, Columbus, OH, 43210, USA. **On-Field Ohio! Considerations and Implications for Measuring Total Phosphorus and Suspended Sediment.**

There are several methods and variations of sample preparation reagents as well as analysis procedures for determining runoff total phosphorus (TP). We compared the performance of three persulfate digestion methods (Acid Persulfate, USGS, and Alkaline Persulfate) for TP percent recovery across a wide range of suspended sediments (SS), and evaluated the ability of using Al and/or Fe in digestion solution to predict SS as a surrogate to the traditional gravimetric method. The Acid Persulfate method was most effective, with an average TP percent recovery of 96.6%. The second most effective method was the USGS with an average TP recovery of 76.1%. However, the Alkaline Persulfate method performed poorly with an average 24.5% TP recovery. As a result application of Alkaline Persulfate digestion to edge of field monitoring will drastically underestimated runoff TP at elevated SS levels. In addition to excellent recovery of TP, the Acid Persulfate method combined with analysis of Al and Fe by inductively coupled plasma atomic emission spectrometry provides a robust estimate of runoff total SS. The implications of accurately measuring TP and SS are demonstrated using statewide simulations for potential edge of field runoff phosphorus loading in Ohio. *Keywords: Sediment transport, Water quality, Phosphorus.*

WHITE, C.J., FOUBISTER, D.D., and WILKIE, M.P., Wilfrid Laurier University, 75 University Ave, Waterloo, ON, N2L3C5, CANADA. **Forensic Markers of Lampricide Toxicity.**

Invasive sea lamprey (*Petromyzon marinus*) populations are controlled with lampricides TFM (3-trifluoromethyl-4-nitrophenol) and niclosamide in the Great Lakes, with minimal non-target effects, although non-target mortalities occasionally occur. Investigations of non-target mortality can be complex due to time of death and decomposition of the fish. It is important to determine the cause of death in fishes following a treatment, and be able to relate to lampricide use or other causes. Indeed, fish kills can occur for many reasons besides lampricide use such as aquatic contaminants, oxygen depletion, and/or disease. The stability of TFM, niclosamide and their metabolites in decomposing fish tissues is unknown; such information is needed for determining the cause of a fish kill after a lampricide application. Using forensic toxicology, the stability of TFM, niclosamide and their metabolites will be quantified in different tissues collected from rainbow trout (Oncorhynchus mykiss) left to decompose in water and in air. This study will identify the forensic markers of lampricide toxicity that can ultimately be used in the development of standard operating procedures and criteria that can be used in the rare circumstances where death may have resulted from lampricide exposure. *Keywords: Fish, Lampricide, Fish toxins, Bioaccumulation.*

WHITMORE, E.A., WATKINS, J.M., and RUDSTAM, L.G., Cornell University, Department of Natural Resources, 110 Fernow Hall, Ithaca, NY, 14853, USA. **Planning for the Detection of invasive zooplankton in the Great Lakes using DNA barcoding.**

DNA barcoding is a method for species identification that uses cytochrome *c* oxidase I (COI) sequences in DNA instead of an entire chromosome or genome. This method allows for faster and cheaper species identification than other genetic sequencing methods. DNA barcoding data has been accumulating in publicly available databases for more than a decade, making it easier to identify cryptic and uncommon species. In order to assist managers in monitoring invasive and rare zooplankton species; the GLNPO monitoring program samples rotifers, cladocerans, and copepods with nets throughout the Great Lakes. For 2012-2014, we evaluated diversity of native and invasive species and identified which species have insufficient (<5) barcode records. If Great Lakes native, non-native and potential invader species have more DNA barcodes publically available lake managers would be able to quickly identify an invasive species and monitor their spread. Amongst the Great Lakes Erie has the most species present and highest proportion of species with insufficient barcodes. In contrast, most Lake Superior crustacean species have barcodes available. We foresee that species present in all lakes except Lake Erie can be barcoded in the next 3 to 5 years and bulk processing for crustacean zooplankton species composition can become cost effective. *Keywords: Genetics, Rotifer, Zooplankton, Management.*

WICK, M.W.[1], LIETZ, J.E.[2], and PAWLOWSKI, M.B.[1], [1]Oak Ridge Institute for Science and Education, Duluth, MN, USA; [2]CSRA, Duluth, MN, USA. **Using National Coastal Condition Assessment Underwater Video to investigate nearshore substrate type.**

A comprehensive method for describing bottom types in Great Lakes nearshore regions (<30 m deep and <5 km from shore) would enhance our ability to target bio-monitoring and restoration efforts. Dredges are ineffective at sampling hard bottoms (bedrock/boulder/cobble) and other habitat features. We attempted to map bottom types using underwater videos collected as part of EPA's National Coastal Condition Assessments (NCCA; 2009-2016). The probability-based sampling design allowed area-based estimates of bottom types. Across all lakes in 2010, soft sediments (sand/silt/clay) constituted 78% of nearshore area, hard substrates constituted 11%, and 10% of the area was classified as unknown. Interestingly, <1% of Lake Huron area was found to be hard substrate. Comparing video results to Ponar-derived substrates found general agreement for soft substrate sites. For hard substrates, Ponars had high rates of sampling failure and thus more disagreement with video results. Underwater video can help improve our understanding of substrate type distribution in the Great Lakes. Improvements in video technology, and deployment and analytical procedures will allow us to better distinguish substrate type to a finer scale, and evaluate additional benthic habitat features like vegetation cover, structure, and type. *Keywords: Sediments, Substrate, Underwater video.*

WICKS, A.W., KRABBENHOFT, T.J., and DOWLING, T.E., Wayne State University, 1360 Bio Science Bldg, Detroit, MI, 48202, USA. **Gene expression variation in round goby and Johnny darter in two Southeast Michigan streams.**

Organisms vary in their response to abiotic and biotic factors, with environmental heterogeneity leading to variation in physiological responses. We used RNA-seq to test the hypothesis that invasive round goby (Neogobius melanostomus) exhibit different responses to environmental heterogeneity as compared to native Johnny darter (Etheostoma nigrum). Our prediction was that the native darter would exhibit greater variation in gene expression among rivers than round goby. By characterizing variation in gene expression we can understand the contribution of hierarchical structure, demographics, and environmental factors to variation in patterns of gene expression. Differential expression analysis was applied to these two common fishes from two Southeastern Michigan drainages, the Rouge and Clinton rivers. In Johnny darters 25 genes showed significant variation in patterns of gene expression, with differences attributable to variation between sexes and between rivers. Differences between sites within the same river were minimal. Sources of variation in round goby were less clear and further work is needed to clarify the observed patterns.
Keywords: Exotic species, Genomics, Fish.

WIEGAND, P.S. and FLINDERS, C.A., NCASI, 1513 Walnut Street, Suite 200, Cary, NC, 27511, USA. **A View on the Intersection of Aquatic Science and the Forest Products Industry.**

Forest products industry investments in North America, and especially the Great Lakes region, are significant. Facilities continue to expand their efforts to operate in concert with evolving environmental objectives and with the communities vested in these operations. This presentation will describe the intersection of the forest products industry in the Great Lakes with the associated aquatic environments. An area of focus will be the industry's commitment to advanced research as exemplified by a 20-year study of four rivers. In these rivers, water chemistry and comprehensive aquatic assessments including periphyton, benthic macroinvertebrates and fish assemblages have been undertaken seasonally at multiple sites on each river over approximately 10-30 miles of reach. The investigation aims to gather data and assess temporal and spatial patterns in aquatic fauna and the influence of pulp mill discharges in these reaches. While the value of such data may be considered in numerous contexts, discussions during this presentation will highlight the need for thoughtful characterization of ecosystem health over time and space. Measures used by environmental managers when implementing programs aimed at environmental protection and improvement will also be considered in this context using examples relevant to the Great Lakes. *Keywords: Forest products, Water quality, Pulp and paper, Environmental effects, Standards and criteria.*

WIGREN, P.L.[1], CHIOTTI, J.A.[1], BRIGGS, A.S.[1], BOASE, J.C.[1], ROSEMAN, E.F.[2], and WILLS, T.C.[3], [1]U.S. Fish and Wildlife Service-Alpena Fish and Wildlife Conservation Office, Waterford Substation, 7806 Gale Road, Waterford, MI, 48327, USA; [2]U.S. Geological Survey, Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105, USA; [3]Michigan Department of Natural Resources, Lake St. Clair Fish Research Station, 33135 South River Rd., Harrison Township, MI, 48045, USA. **Adult Fish Response to Artificial Reefs Constructed in the St. Clair - Detroit River System.**

The St. Clair - Detroit River System (SCDRS) once supported a diverse and productive fishery. However, beginning in 1874, both rivers were extensively modified, changing the flow and damaging the expansive natural limestone reefs. Populations of valuable lithophilic spawning fishes declined or were extirpated. Since 2004, seven artificial reefs totaling over 16 acres have been constructed in the SCDRS to replace lost habitat. In order to evaluate the adult fish community response to reef construction, gill nets were deployed in spring and fall each year. Using a Before-After-Control-Impact (BACI) study design, the relative abundance of target fish species was evaluated along with species presence/absence prior to and after construction. Four new species were captured in gill

nets post construction that were not detected during pre-construction assessments. There was no statistically significant difference in catch per unit effort (CPUE) of the most common captured species (walleye, white sucker, and redhorse species) prior to and after construction. However, mean CPUE for each species was greater during the post construction time period. This work continues to document native fish use of reefs following construction and highlights the difficulty in detecting measurable changes at large spatial scales. *Keywords: Bioindicators, Detroit River, St. Clair River.*

WILSON, R.[1], ZHANG, W.[2], IRWIN, E.[1], ALOYSIUS, N.[1], and MARTIN, J.[1], [1]The Ohio State University, Columbus, OH, 43210, USA; [2]Iowa State University, Ames, IA, 50011, USA. **The role of farmer efficacy in improving water quality.**

Non-point source runoff from agricultural production is impairing coastal ecosystems and related services across the globe. This degradation is projected to worsen with climate change in the upper Midwest, as more intense rains transport more nutrients downstream. To combat these problems, agricultural best management practices (BMPs) have been advocated, but voluntary farmer adoption has proven insufficient to date. Using the western Lake Erie Basin as a model ecosystem, we conducted a mail survey of conventional corn-soybean farmers to develop a farmer decision-making model as part of a larger coupled human-natural system. Results indicate that adoption of recommended best practices increases with greater confidence in one's ability to implement the practice and a stronger belief in the practice's ability to reduce nutrient loss and improve water quality. For example, increasing perceived efficacy by just 20% from baseline levels increases the probability of adoption for a given individual by approximately 10%. We use a spatially-explicit coupled human-natural systems model to evaluate the likelihood of achieving the targeted 40% reduction in phosphorus loading to Lake Erie through a combination of incentive payments and efficacy-building outreach and education. *Keywords: Policy making, Farmer behavior, Outreach, Nutrient management, Harmful algal blooms.*

WIMMER, E.E.[1], MCNAUGHT, A.S.[1], and MARSDEN, J.E.[2], [1]Central Michigan University, Mount Pleasant, MI, USA; [2]University of Vermont, Burlington, VT, USA. **Importance of *Hemimysis anomala* in the Diets of Lake Trout Fry on Nearshore Reefs.**

Nearshore habitats such as rocky reefs in the Great Lakes have become increasingly important to ecosystem function and host a collection of benthic invasive species including the bloody red shrimp (*Hemimysis anomala*). Additionally, rocky reefs are utilized as spawning grounds for deep-water fishes including the ecologically and economically valuable lake trout (*Salvelinus namaycush*), an apex predator that was largely extirpated from the Great Lakes by

the 1960s due to commercial overfishing and sea lamprey invasion. Within their first year lake trout mortality is largely due to starvation or predation. To test whether juvenile lake trout will feed on *Hemimysis* if given the opportunity, replicated laboratory feeding trials on 100 mm lake trout fry were conducted for 15, 30, 60, and 120 minutes using small and large *Hemimysis*. As feeding time increased, the number of*Hemimysis* consumed increased, and there were no differences in consumption rates between small and large *Hemimysis*. The percent *Hemimysis* consumed among time and prey sizes were analyzed using a 2-way ANOVA. Our results suggest that the presence of *Hemimysis* on rocky reefs when lake trout fry begin feeding could provide an abundant and much needed food source. *Keywords: Lake trout, Hemimysis anomala, Invasive species, Native fish restoration, Lake model.*

WINTER, C.L.[1], AXNESS, K.[2], O'SHEA, M.C.[3], and O'DONNELL, T.K.[4], [1]ORISE fellow at U.S. EPA, Chicago, IL, USA; [2]Wisconsin Department of Natural Resources, 101 South Webster St, Madison, WI, 53707, USA; [3]Wisconsin Department of Natural Resources, 2984 Shawano Ave, Green Bay, WI, 54313, USA; [4]EPA Great Lakes National Program Office, 77 W. Jackson Blvd, Chicago, IL, 60604, USA. **Current Approach to the Lower Green Bay and Fox River AOC Eutrophication BUI.**

The Great Lakes Restoration Initiative (GLRI) has accelerated progress in U.S. Areas of Concern (AOCs) by providing funds for actions needed to restore beneficial use impairments (BUIs). To prioritize GLRI funds and demonstrate progress, the U.S. Environmental Protection Agency (EPA) developed the concept of "near term AOCs." Near-term AOCs are those that are recognized as having achievable BUI delisting targets and a complete set of management actions. The Lower Green Bay and Fox River AOC in northeastern Wisconsin has 13 of the 14 possible BUIs, including Eutrophication or Undesirable Algae. Developing a management action list for this BUI is challenging because watershed sources beyond the AOC boundary contribute to Green Bay eutrophication. Therefore, charting the path for the BUI requires defining the contribution that the AOC can make toward a larger watershed effort. The Wisconsin Department of Natural Resources has engaged stakeholders and EPA in revising the delisting target and developing a management action list with the goal of attaining near term AOC status. The conceptual framework for the discussions has been to match "something to do" with "something to measure" while finding a balance of "meaningful, measurable, and achievable" that is accepted by all participants in the process. *Keywords: Great Lakes basin, Green Bay, Eutrophication.*

WOLIN, J.A., DUNLEAVY, M., BIENVENU, T., OSTRY, J., and VISNAUSKAS, A., Cleveland State University, 2121 Euclid Ave, Cleveland, OH, 44115, USA. **Assessing the Role of Urban Lakes in Water Quality Management.**

To better understand the functional role of water bodies in urban and suburban regions of the Great Lakes basin, we conducted a county-wide assessment of lakes, reservoirs, and retention ponds in Cuyahoga County, Ohio in 2013. Physical characteristics, surrounding land use, waterfowl presence, shoreline vegetation, water chemistry, microcystin, and surface sediments for diatom analysis were sampled at forty sites following protocols developed for the 2012 US National Lake Assessment (NLA) and the Ohio EPA Inland Lake Water Quality Monitoring Program. Surveys were conducted to determine lake management practices i.e. fertilizer use, dredging, and method of algal control. Grass was the dominant shoreline vegetation. Our results indicate 40-50% of the sample sites had poor shoreline habitat, comparable to 41% of man-made lakes found in the 2007 NLA. Visual algal assessment indicated moderate to extensive algae in 34% and detectable algae in 57% of the lakes. Visible *Microcystis* was found at 50% of the sites, while microcystin concentrations above WHO drinking water guidelines of 1ug/l were only found in three lakes. Surface sediment diatom community analysis indicate dominant factors contributing to lake condition are nutrient gradients and depth. *Keywords: Algae, Water quality, Urban watersheds.*

WOLLER-SKAR, M.M.[1], RESS, J.A.[1], and THOMAS, E.W.[2], [1]Dept of Biology, Grand Valley State University, Allendale, MI, 49401, USA; [2]Dept of Biology, MacMurray College, Jacksonville, IL, 62650, USA. **Using algal communities to assess wetland restoration efficacy.**

Wetland ecosystems provide numerous ecosystem services such as wildlife habitat, flooding mitigation and carbon sequestration. Despite these services, wetlands continue to decline in area. Restoration efforts include these ecosystems, often based on their importance and rarity. The purpose of this project was to assess restoration efforts of ephemeral wetlands using algal community assemblages. We collected 174 samples of benthic algae from 33 vernal pools (20 restored, 13 natural) located on Travis Air Force Base, Fairfield, CA from January-March 2016. Preliminary comparisons using non-metric multidimensional scaling indicated that algal communities in natural and restored pools were significantly different (Adonis post hoc test: $F=2.092$, $df=1$, $p=0.043$), whereas principal component analyses of water and soil temperatures, depths and soil pH values suggested that natural and restored pools had similar abiotic conditions. Although the implications of different algal communities in restored ephemeral wetlands are unknown, if the goal of a project is to restore the native or original community, the algal community must be considered. *Keywords: Algae, Restoration, Wetlands.*

WOOD, N.J., Central Michigan University, Mount Pleasant, MI, USA. **Live streaming your science: The engaging platforms of Periscope and FacebookLive.**

Science communication is nothing new for scientists. Traditionally researchers have communicated with their intended audiences via print or television. Emerging technologies have changed how we as a society communicate and scientists must update their communication tools so they don't lose touch with their audiences. Social media platforms such as Facebook, Twitter, and Instagram allow researchers to engage with audiences directly, enabling for a greater exchange of information. While these apps foster a dynamic interaction, they still lack that personal touch of being able to engage with a "real live" scientist rather than just words on a screen. Apps such as Periscope and FacebookLive let a broadcaster live stream a video/audio feed via their phone, tablet, or computer directly to their audience and viewers can communicate back in real time to the broadcaster through an integrated chat module during the broadcast. Live streaming can be used for a wide variety of science communication options such as interviews, research presentations, fieldwork showcases, and more. Science communication is an ever-evolving set of tools for the scientist's toolbox. Live streaming is a tool that can be easily added and one that researchers must take advantage of to stay relevant in today's social media world. *Keywords: Outreach, Science Communication, Public education, #scicomm, Social Media.*

WU, C.H. and ANDERSON, J.D., University of Wisconsin-Madison, Madison, WI, 53706, USA. **Freak Waves in the Apostle Islands, Lake Superior: Characteristics and Occurrence.**

Freak (or rogue) waves are unexpectedly large and transient waves that cause notorious hazards to navigation vessels. Freak waves commonly occur as the "Three Sisters" phenomenon for depicting a series of three large waves are believed to the cause of the sinking the SS Edmund Fitzgerald on Lake Superior. In this talk, freak waves at three nearshore locations in the Apostle Islands, Lake Superior are characterized for the first time in the Great Lakes. Analysis of geometric qualities of freak waves show that freak waves can take a variety of shapes but generally have steeper profiles and greater asymmetry than normal waves, consistent with freak waves observed in the oceans. freak waves can occur in a wide range of different sea states characterized by spectral steepness and bandwidth, suggesting that there is always potential for a freak wave to occur. The occurrence probability of freak waves is related to the spectral bandwidth with freak waves being approximately 3 times more likely during narrow than broad-banded seas. Furthermore, both spatial focusing effects and wave breaking can affect the occurrence of freak waves in the nearshore of Lake Superior. *Keywords: Waves, Hydrodynamics, Coastal processes.*

WYNNE, T.T.[1], STUMPF, R.P.[1], MEREDITH, A.[2], DAVIS, T.W.[3], MISHRA, S.[2], and TOMLINSON, M.C.[1], [1]NOAA National Ocean Service, National Centers for Coastal Ocean Science, Silver Spring, MD, 20910, USA; [2]CSS-Dynamac, Silver Spring, MD, 20910, USA; [3]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, 48108, USA. **Variability in Cyanobacterial Bloom Biomass in Saginaw Bay.**

Saginaw Bay, off Lake Huron in Michigan, has experienced algal blooms, especially cyanobacterial blooms in recent decades. Details on the characteristics and phenology of these blooms will help in understanding the impacts of phosphorus reduction strategies for the Saginaw River. Satellite data from the MODIS sensor on Aqua and Terra satellites provides a time series from 1999 to 2016. MODIS data sets were processed using the standard methods for detecting and mapping probable cyanobacterial blooms that have been developed for Lake Erie. The spatial and temporal patterns of the blooms were identified, and total biomass estimated. Saginaw Bay has much less inter-annual variation in biomass then the western Lake Erie basin (WLEB), and much smaller total estimated biomass. The Saginaw River basin produces about 1/4 of the annual total phosphorus load of the Maumee River into the WLEB, and the Bay and WLEB are of similar size, indicating that the two should differ in the amount of cyanobacterial biomass. *Keywords: Harmful algal blooms, Lake Huron, Phosphorus.*

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XIAO, C.[1], LOFGREN, B.M.[2], GRONEWOLD, A.D.[2], GOCHIS, D.[3], MASON, L.[1], and PEI, L.[3], [1]Cooperative Institute for Limnology and Ecosystems Research (CILER), University of Michigan, 4840 S. State Rd., Ann Arbor, MI, 48108, USA; [2]NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Rd., Ann Arbor, MI, 48108, USA; [3]National Center for Atmospheric Research (NCAR), P.O. Box 3000, Boulder, CO, 80307, USA. **Implementing the WRF-Hydro Modeling System in the Great Lakes Region.**

As a physics-based, spatially-distributed hydrologic modeling system, the community Weather Research and Forecasting model (WRF) hydrological extension package (WRF-Hydro) has been used in several streamflow prediction applications in the U.S. and around the world, including the National Water Model (NWM) at the newly established NOAA National Water Center. However, because of lack of consistency of the geofabric data along the U.S. and Canada borders, the Great Lakes basin is not entirely included in NWM, leaving a substantial gap for applying the national model to the water-dominated region. Thus, a specific effort has been devoted to implementing the WRF-Hydro modeling system in the Great Lakes basin, including preparing high-resolution terrain datasets, parameterizing lakes

and reservoirs, and calibrating the model. Two experiments have been carried out to support implementation of the NWM in the Great Lakes basin: an offline WRF-Hydro simulation forced by NLDAS2 and a coupled WRF/WRF-Hydro simulation. The model results are validated against observations in terms of precipitation, runoff, soil moisture, channel flow, and land surface heat fluxes. Our preliminary study presented here shows that the WRF-Hydro model is capable of reproducing the land-hydro-air feedbacks in the Great Lakes region. *Keywords: Hydrodynamic model, Atmosphere-lake interaction, Model studies.*

XU, H.[1], PAERL, H.W.[2], and ZHU, G.W.[1], [1]Nanjing Institute of Geography & Limnology, Chinese Academy of Sciences, 73 East Beijing Road, Nanjing, 210008, CHINA; [2]University of North Carolina at Chapel Hill, Institute of Marine Sciences, Arendell Stree, Morehead citty, NC, 28557, USA. **The roles of external vs internal nutrient sources in Cyanobacterial bloom in Lake Taihu, China.**

Harmful cyanobacterial blooms (CyanoHABs) are a troubling indicator of accelerating eutrophication. Lake Taihu is the third largest freshwater lake in China.Since the 1980's rapid economic development and population growth in the Taihu Basin has led to increasingly severe and frequent CyanoHABs. In the present work, multi-year quarterly, monthly and weekly multi-site monitoring datasets were analyzed to understand seasonal dynamics of N and P concentrations and inventories, and cyanobacterial bloom in lake. Nutrient mass budgets were constructed to estimate internal P release from sediments and N loss via denitrification. The links between system-wide denitrification, and P release from sediments and CyanoHAB cyanobacterial bloom potential were assessed. This helped clarify the roles and relative importance of internal cycling processes versus external nutrient inputs in the development, magnitudes and duration of CyanoHABs in Taihu. *Keywords: Lake Taihu, Phytoplankton, Cyanobacterial bloom, Phosphorus, Microcystis, Eutrophication.*

XUE, P.[1], CHU, P.[2], YE, X.[1], and LANG, G.A.[2], [1]Michigan Technological University, 1400 Townsend Dr., Houghton, MI, 49931, USA; [2]NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Rd., Ann Arbor, MI, USA. **Improve Lake Erie Thermal Structure Predictions using Data Assimilative Hydrodynamic Model.**

Numerical models have been used to study the thermal structure and circulation of the Great Lakes since the mid 1970's. NOAA developed the first three-dimensional hydrodynamic model in the 1990's and has been providing operational short-term forecast products for Lake Erie since 2005. Numerous validation and skill assessments showed that most models have good skills in simulating lake surface temperature, but higher uncertainty still remains in simulating sub-surface temperature and overall thermal structure. Data assimilation has been used in meteorology and oceanography communities to provide optimized estimation of the system state and improve short-term forecasting by blending observational data into a dynamic model. In this study, mooring and buoy temperature data collected from the International Field Year of Lake Erie (IFYLE) have been incorporated into a data-assimilative hydrodynamic model FVCOM. Model improvements in simulating Lake Erie temperature and thermal structure through data assimilation are presented, and data sampling strategies to assist model forecasting are discussed. *Keywords: Hydrodynamic model, Data assimilation, Lake Erie, IFYLE.*

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YANG, B.[1], WELLS, M.G.[1], YOUNG, J.[2], and BROWN, L.C.[3], [1]University of Toronto Scarborough, 1095 Military Trail, Toronto, ON, M1C1A4, CANADA; [2]Ontario Ministry of the Environment and Climate Change, 125 Resources Road, Toronto, ON, M9P 3V6, CANADA; [3]University of Toronto Mississauga, 3359 Mississauga Road, Mississauga, ON, L5L 1C6, CANADA. **High frequency observations of radiatively driven convection under winter ice in Lake Simcoe.**

High-frequency observations of thermal structure under the ice of the large Lake Simcoe reveal the presence of large (10-20 m) overturning convection cells, driven by diurnal solar heating. The most vigorous convection occurred near the end of winter, which our model suggest is the time that the ice melted, thinned and became transparent. This convection lead to a deepening of the mixed layer over time. During the same period the dissolved oxygen had become super-saturated from the surface to 23 m below the surface, suggesting abundant algal growth. Thorpe scale analysis of our high frequency temperature measurements, revealed that very large scale mixing occurred beneath the ice. This mixed layer depth increased during the melting period, and mixing was most active during the day. Our observations over two winters suggest that end of winter under-ice dynamics can be very important for oxygen budgets in the many northern ice covered lakes. *Keywords: Lake Simcoe, Ice, Water currents.*

YAO, S.H.[1], DROUILLARD, K.G.[1], HAFFNER, G.D.[1], LI, J.J.[1], ZHANG, L.[2], and WANG, D.Y.[2], [1]Great Lakes Institute for Enviromental Research, 2990 Riverside Drive, West, Windsor, on, N8N4S3, CANADA; [2]Southwest University, NO.1 Tiansheng Rd, Beibei, Chongqing, 400715, CHINA. **Comparison of contaminant accumulation in silver carp and bighead carp from Three Gorges Reservoir and Mississippi River.**

Asian carp, including bighead carp (*Hypophthalmichthys nobilis*) and silver carp (*Hypophthalmichthys molitrix*) are a major threat to the Great Lakes as they have established

large populations in the Mississipi River and are suspected of having entered Lake Michigan. As planktivores, these species occupy a low trophic status and also exhibit very fast growth rates which reduce their tendency to bioaccumulate toxic contaminants. In China, these species of fish are highly sought after as food fish and stocked into many water bodies including the Three Gorges Reservoir. This study compares contaminant accumulation in silver carp and bighead carp collected from Three Gorges Reservoir and Mississippi River. PCBs, organochlorine pesticides, total mercury and methylmercury were examined in each specimen. Contaminant profiles were further compared using multivariate techniques. Organochlorine contamination was observed to be similar and low relative to fish consumption advisory thresholds in both populations. Mercury residues showed high contamination in North America fish, but still below concentrations warranting concern. *Keywords: Bioaccumulation, Carp, Invasive species.*

YE, X.[1], XUE, P.[1], PAL, J.S.[2], LENTERS, J.D.[3], and CHU, P.[4], [1]Michigan Technological University, Houghton, MI, USA; [2]Loyola Marymount University, Los Angeles, CA, USA; [3]University of Colorado at Boulder, Boulder, CO, USA; [4]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, USA. **Coupling a Regional Climate Model with a 3-D Hydrodynamic Model over the Great Lakes.**

Accurate representations of lake-ice-atmosphere interactions in regional climate modeling remain one of the most critical and unresolved issues for understanding large-lake ecosystems and their watersheds. To date, the representation of the Great Lakes two-way interactions in regional climate models is achieved with 1-D lake models applied at the atmospheric model lake grid points distributed spatially across a 2-D domain. While some progress has been made in refining 1-D lake model processes, such models are fundamentally incapable of realistically resolving a number of physical processes in the Great Lakes. In this study we develop a two-way coupled 3-D lake-ice-climate modeling system [Great Lakes-Atmosphere Regional Model (GLARM)] aimed at improving the simulation of large lakes in regional climate models and accurately resolving the hydroclimatic interactions. Model results are compared to a wide variety of observational data and demonstrate the unique skill of the coupled 3-D modeling system in reproducing trends and variability in the Great Lakes regional climate, as well as in capturing the physical characteristics of the Great Lakes by fully resolving the lake hydrodynamics. *Keywords: Coupled regional climate model, Lake-atmosphere feedbacks, The Great Lakes.*

YOUNG, L.C., ASHER, J.A., O'NEIL, G., PIWARSKI, J.R., ANDERSON, V., and BARTHOLIC, J.F., Michigan State University Institute of Water Research, 1405 S Harrison

Rd 101A Manly Miles, East Lansing, MI, 48823, USA. **Empowering Farmers and Partners of Agriculture with Strategic Online Conservation Tools.**

The Sensitive Areas Identification System (SAIS) and Great Lakes Watershed Management System (GLWMS) are online conservation tools that strengthen interactions between farmers and partners of agriculture to prioritize conservation efforts, plan appropriate conservation treatments, and track water quality benefits of such practices. SAIS serves as a preliminary planning and inventory tool by mapping ecologically sensitive areas that may be prone to soil erosion, nutrient leaching or other risks; calculating phosphorus and manure indices; and suggesting potential conservation treatments. The GLWMS extends conservation planning by allowing users to evaluate the impacts conservation practices have on groundwater recharge levels and sediment and nutrient loading. Furthermore, the GLWMS saves implemented practices and aggregates their associated benefits across watersheds, making this system a valuable resource for tracking water quality improvements. This presentation will highlight how these tools function as a strategic package, empowering agricultural stakeholders to reduce nutrient loss and improve on-farm decision-making.
Keywords: Water quality, Conservation, Decision making.

<u>YOUNG, R.T.</u>[1], KRIEGER, J.R.[1], DEBRUYNE, R.L.[2], ROSEMAN, E.F.[2], and DIANA, J.S.[1], [1]University of Michigan, 440 Church St., Ann Arbor, MI, 48109, USA; [2]U.S. Geological Survey, 1451 Green Rd., Ann Arbor, MI, 48105, USA. **Assessing the spatiotemporal distribution of larval Lake Sturgeon in the St. Clair River, Michigan.**

Historically, the St. Clair River (SCR) provided ample spawning grounds for Lake Sturgeon (*Acipenser fulvescens*). Excessive harvest, habitat loss and pollution have reduced Lake Sturgeon numbers to less than 1% of their historic abundance. In efforts to facilitate Lake Sturgeon recovery, research about early life history requirements and their relationship to recruitment is ongoing. These studies are difficult in large rivers due to the challenges associated with capturing fish and monitoring their movements in deep, swift waters. From 2013 to 2014, we deployed a series of D-frame drift nets to examine the relationship between larvae catch-per-effort (CPE), biotic and abiotic factors in the lower SCR. Annual catch in the drift nets was 163 larvae during 1,181 hours of sampling between 10 June and 9 July 2013 (14 nights); and 680 larvae during 1,979 hours of sampling between 8 June and 29 July 2014 (23 nights). CPE of drifting larvae was highest at upstream sample locations. Size and stage data showed evidence of protracted spawning. Our research identified habitat use and ecological interactions influencing larval survival in the lower SCR. This information advances our understanding of larval drift in large rivers, allowing managers to develop more effective Lake Sturgeon rehabilitation strategies. *Keywords: Fish populations, Lake Sturgeon, St. Clair River, Life history studies.*

YU, A.W.[1], MOUW, C.B.[2], and MOORE, T.S.[3], [1]Michigan Technological University, 1400 Townsend Drive, Houghton, MI, 49931, USA; [2]University of Rhode Island, 215 South Ferry Road, Narragansett, RI, 02882, USA; [3]University of New Hampshire, Durham, NH, 03824, USA. **Evaluating the Influence of the Detroit River on Algal Bloom Distribution in Western Lake Erie.**

Harmful algal blooms (HABs) in western Lake Erie have significant ecological and socioeconomic impacts, depending on the size and intensity of the bloom. Agricultural fertilizer runoff, strong storms with heavy rains and high winds, and weak lake wide circulation patterns have been attributed as causes for bloom initiation. However, the influences from these ecological and physical drivers on the temporal evolution of bloom spatial distribution are not well understood. In this study, we analyze a hydrodynamic model in combination with satellite imagery, continuous in water measurements from the summers of 2013 and 2014, *in situ* field samples, meteorological observations, and river flow data to investigate the impact of the Detroit River on the distribution of HABs in Lake Erie. Waters from the Detroit River were identified through optical and electrochemical signals and were differentiated from other waters of the western basin. The results reveal the degree of influence on bloom dispersal and mixing from the Detroit River and provide new insight into the impacts of this river on the drivers of bloom temporal and spatial variability. Additionally, results from this project will help assist environmental monitoring programs to understand bloom movement, distribution, and initiation. *Keywords: Harmful algal blooms, Lake Erie, Detroit River.*

YU, L.[2], ZHU, G.W.[2], XU, H.[1], ZHU, M.Y.[1], and QIN, B.Q.[2], [1]Nanjing Institute of Geography and Limnology, 73 East Beijing Road, Nanjing, JS, 210008, CHINA; [2]Taihu Laborabory for Lake Ecosystem Research, WuXi, CHINA. **The dynamics of toxic cyanobacteria and microcystins and associations with environmental factors in.**

Lake Taihu, the third largest freshwater lake in China, is suffering from serious toxic cyanobacterial blooms. The associated drinking water sources serve for millions of citizens around the lake were under the risk of microcystins contamination. In this study, the water samples for DNA, microcystins, and related environmental parameters were collected weekly from eight intakes of drinking water plants of Wuxi and Suzhou in 2016. The dynamics of toxic cyanobacteria and microcystins concentrations are measured to evaluate their effects on water quality in these water sources. The results showed that the microcystins concentrations are highly varied with time and space, and closely related to the abundance and proportion of toxic Microcystis. Meanwhile, temperature, nutrients and heavy rainfall are key environmental factors driving the dynamics of toxic cyanobacteria and microcystins in this hypereutrophic lake. This study highlights the fact that future climate warming,

eutrophication, coupled with extreme weather events have great effect on the population structure of toxic cyanobacteria and microcystins levels in freshwater. The research also benefits the risk forecasting of toxic cyanobacteria bloom and water safety in drinking water source of eutrophic lakes. *Keywords: Drinking water intakes, Drinking water, Microcystins, Environmental effects, Lake Taihu.*

YUAN, F., Cleveland State University, 2121 Euclid Ave, Cleveland, OH, 44115, USA. **Enhanced Transfer and Cycling of Trace Metals and Plant Nutrients in Lake Erie.**

Concentrations of Al, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, P, Pb, Mg, Mn, Mo, Ni, K, Se, Na, Sn, Sr, Ti, V, and Zn were measured on surface and cored sediment samples collected from the western and Sandusky basins. These results allowed us to evaluate the spatial and temporal changes in the complex ecosystem. Although many of the trace elemental inputs into Lake Erie have reduced considerably since the enactments of stringent regulations in the early 1970s, the concurrent reductions in these basins have been much less than expected. A large increase in the release of these elements from local storage (internal loading) is required to account for the slow recovery or even no recovery in some areas. The increased internal loading is believed to be associated with changes in the lake's trophic state, biological productivity, hydrology and biogeochemistry. We argued that increased organic matter from long-lasting eutrophication facilitated to enhance the transfer, transport, and cycling of many trace metals and plant nutrients in the lake. This work showed that the complex lake ecosystem including the internal loading has changed considerably over the past century. Further research to better understand the increased rates of elemental transfer and transformations is badly needed for addressing the "re-eutrophication" problem. *Keywords: Biogeochemical cycling, Sediment resuspension, Phosphorus, Lake Erie, Trace metals, Water level fluctuations.*

Z

ZACK, S.A.[1], DUHAIME, M.[2], and FOLEY, C.J.[3], [1]Illinois-Indiana Sea Grant, Chicago, IL, USA; [2]University of Michigan, Ann Arbor, MI, USA; [3]Illinois-Indiana Sea Grant, West Lafayette, IN, USA. **Microplastics in the Laurentian Great Lakes: Facilitated Discussion.**

The negative ecosystem impacts of anthropogenic plastic debris in marine ecosystems are well-documented and include ingestion by and entanglement of animals as well as increased transport of hydrophobic contaminants. Recently, a new focus of concern has emerged: microplastics. This land-based marine debris includes plastic particles of varying shapes, e.g., beads, fibers, that are less than 5 millimeters in size. Researchers have begun to describe the abundance and location of these microplastics in the Laurentian Great Lakes region, including in sediment, tributary waters, and wastewater treatment plant effluent. However, there is continued interest in the fate of these particles and their impact on food web dynamics, particularly in freshwater systems. Following all presentations in this session, chairs will utilize this time to facilitate discussion to build on previous and inform future efforts regarding anthropogenic plastics research and outreach in the Great Lakes region. *Keywords: Pollution sources, Environmental effects, Microplastics.*

ZALOGA, A., PAWLOWICZ, R., and PIETERS, R., University of British Columbia, Vancouver, CANADA. **Spatial and Temporal Variability of Double Diffusive Structures in Powell Lake, BC.**

Double diffusive convection (DDC) is a naturally occurring process in oceans and saline lakes, which appears in regions where salinity (S) and temperature (T) gradients oppose one another, and leads to the formation of vertically stacked layers of convection with diffusive boundaries. These layers play an important role in governing the vertical heat flux in these areas, and can be easily identified from their characteristic appearance as a `staircase' structure in vertical profiles of S and T. Powell Lake, in British Columbia, is one such lake in which DDC is present due to the gradients created by the geothermally heated relic sea water trapped at its bottom, and cooler, fresh water at its surface. Three years of vertical S and T sampling along the length of the lake, and a month-long mooring measuring T and currents within a layer, have brought novel observations of the spatial and temporal variations within individual layers, and of the overall staircase structure. Although caused by differences in the diffusivities of salt and heat, the convecting layers observed are around 1m in height, 10km in length, and appear stable over a period of years; however, contrary to this overall stability, significant periodic fluctuations within individual layers have been observed, reinforcing their dynamic nature. *Keywords: Spatial analysis, Mixing processes, Signal processing, Heat fluxes, Physical limnology.*

ZARNETSKE, J.P., Michigan State University, 288 Farm Lane, NS 207, Earth & Environmental Sciences, East Lansing, MI, 48824, USA. **Water Flow, Not Carbon Sources Determines Organic Carbon Flux from U.S. Watersheds.**

Dissolved organic carbon (DOC) is the dominant form of carbon moving from land to rivers to oceans, nearly equivalent to net carbon uptake of all terrestrial ecosystems. This DOC regulates aquatic ecosystem productivity, chemistry, greenhouse gas production, and physical properties such as visibility. Thus, DOC fluxes from terrestrial environments to inland waters is important for understanding aquatic ecosystems and carbon cycling through earth system components. Many physical and biological processes regulate this flux of organic carbon to inland waters, but there is no consensus importance of any particular process, resulting in an inability to predict DOC flux responses to future climate and land use variations. Here, we use ensemble modelling techniques to quantify the relationship between DOC flux and river discharge for 1007 North American catchments with diverse climate and land cover conditions. We found that DOC flux was transport limited (concentration increased with discharge) in 80% of catchments; hydrologic connectivity is the dominant process. Also, wetland area and catchment slope best predicted DOC flux across spatial scales. By modelling DOC flux as a function of discharge and widely available catchment properties, hydrologic DOC flux could be efficiently integrated into coupled carbon and management models. *Keywords: Biogeochemistry, Watersheds, Organic carbon.*

ZASTEPA, A. and WATSON, S.B., Environment and Climate Change Canada, 867 Lakeshore Road, Burlington, ON, CANADA. **Deep-living layers of phytoplankton in oligo-mesotrophic Georgian Bay embayments.**

Deep-living layers of phytoplankton have been reported globally in stratified lakes and can account for the bulk of net primary production in these lakes. Our study in Georgian Bay found embayments dominated by deep-living cyanobacteria, photophagotrophic and autotrophic flagellates (chrysophytes, cryptophytes, dinoflagellates) and diatoms, with annual changes in dominance. Layers were located at the interface between the meta- and hypolimnion, with some near lake-bottom (12 m) and extending over ~ 150 x 500 m2. Despite strong gradients of light, water density, temperature, conductivity, oxygen, nutrients, and sulphide, layers reached levels comparable to sub-surface blooms (~100 μg/L chl a). Presence of colonial bacteria such as Leptothrix in these deep-living communities suggests that biochemical transformations of metals (iron, manganese) may play a role in their success and community structure. Although virtually no microcystin toxins have been detected in layers dominated by cyanobacteria, protein phosphatase inhibition indicates presence of other secondary metabolites relevant to ecosystem structure and health . Deep-living phytoplankton where hypoxia and sediment release of phosphorus are to be managed means caution should be exercised as these layers have been observed to form surface blooms when perturbed. *Keywords: Harmful algal blooms, Deep chlorophyll layers, Great Lakes basin, Deep-living phytoplankton, Water quality, Toxins.*

ZATHEY, N.G. and NEFF, B.D., University of Western Ontario, 1151 Richmond St., London, ON, N6A 3K7, CANADA. **Thermal ecology of juvenile Atlantic salmon.**

Atlantic salmon were once abundant in Lake Ontario but were extirpated by 1900. Recent stocking efforts have released three strains of Atlantic salmon into Lake Ontario, but a self-sustaining population of Atlantic salmon has not yet been established . One factor that may be limiting the success of these stocking efforts is a poor match between the thermal performance of the stocked Atlantic salmon and the thermal environment in Lake Ontario and its tributaries. Our research uses multiple fitness metrics--cardiac performance, swim performance and feeding rate--to quantify differences in thermal performance curves among the three strains of Atlantic salmon and at different rearing temperatures. These laboratory measures are complimented by assessments of thermal microhabitat preference in experimental tanks and natural tributaries. Together these data will contribute to Atlantic salmon management in Lake Ontario by identifying the strains and rearing conditions best-suited for reintroduction into the thermal environment of Lake Ontario. *Keywords: Salmon, Thermal, Fish management, Fish hatcheries.*

ZHANG, F.[1], REID, K.B.[2], and NUDDS, T.D.[1], [1]University of Guelph, 50 Stone Road East, Guelph, ON, N1G2W1, CANADA; [2]Ontario Commercial Fisheries' Association, Blenheim, ON, N0P1A0, CANADA. **Decadal Variation in Stock-recruitment Relationships of Lake Erie Yellow Perch.**

Fish stock-recruitment relationships (SRRs) may change over time with systematic changes in ecological conditions, increasing uncertainty and risk for fisheries managers. Given large changes in Lake Erie ecosystem over several decades, and the long time series fishery data to match, we explored effects of ecosystem changes on SRRs of Lake Erie yellow perch (*Perca flavescens*). We fitted Ricker stock-recruitment models to data for yellow perch populations in four management units (MUs) between 1975 and 2015. SSRs were non-stationary in all four cases, and the variations in productivity (alpha) and density- dependence (beta) were spatially synchronized across MUs and corresponded temporally with the key ecosystem changes. Productivity (alpha) decreased with phosphorus control beginning in the 1970s until the late-1980s following dreissenid invasion; thereafter it increased through mid-1990s. Alpha decreased slightly since mid-1990s with re-eutrophication in the western and west-central basins, but remained relatively stable in the east-central and eastern basins. Opposite trends were observed for beta. These results illustrate the need to incorporate ecological mechanisms in stock-recruitment models to better understand fish population dynamics. *Keywords: Fish populations, Stock-recruitment relationship, Yellow perch, Lake Erie.*

ZHANG, H.[1], ROWE, M.D.[1], JOHENGEN, T.H.[1], ANDERSON, E.J.[2], and RUBERG, S.[2], [1]Cooperative Institute for Limnology and Ecosystems Research, University of Michigan, 4840 S. State Rd., Ann Arbor, MI, 48108, USA; [2]NOAA Great Lakes Environmental

Research Laboratory, 4840 S. State Rd., Ann Arbor, MI, 48108, USA. **Modeling succession of algal functional groups associated with Lake Erie harmful alga blooms.**

Harmful algal blooms (HABs) in Lake Erie have increased in recent years and put ecosystem services at risk. Many modeling studies have shown that external phosphorus loading is a good predictor for HAB occurrence and severity. Few modeling studies show how other environmental factors within the lake affect HAB dynamics and succession over the growing season, including water temperature, light, nutrients, and process parameterizations of algal functional groups. This study used a one-dimensional (vertical column) water quality model with three algal functional groups (green algae, *Microcystis* and diatoms) to test the sensitivity of HAB development to these factors, and to assess how our current knowledge about algae implemented in this model can best predict algal dynamics. The model was driven by water temperature, light, and vertical diffusivity that were output from a three-dimensional hydrodynamic model, Finite-Volume Community Ocean Model (FVCOM). We calibrated the model with observations from weekly monitoring stations in western Lake Erie. Finally, we increased our model complexity from one-dimensional to three-dimensional by coupling this water quality model with the FVCOM to show how horizontal mixing further contributes to the algal dynamics. *Keywords: Water quality, Sensitivity analysis, Harmful algal blooms, Lake Erie.*

ZHANG, Q.[1] and BALL, W.P.[2], [1]USEPA Chesapeake Bay Program / University of Maryland Center for Environmental Science, 410 Severn Ave, Suite 112, Annapolis, MD, 21403, USA; [2]Johns Hopkins University, 3400 North Charles Street, Baltimore, MD, 21218, USA. **Synthesis of Long-term Patterns of Nutrient and Sediment Export from the Chesapeake Bay Watershed.**

Chesapeake Bay, the largest estuary in the North America, has experienced persistent summer hypoxia due to excessive nutrient and sediment inputs from the watershed, which has long been a major concern to managers, scientists, and the public. To assess management progress and help shape future strategies, we have conducted a large-scale synthesis through statistical modeling of decadal-scale water quality data in multiple major tributaries. For the nontidal Bay watershed, total nitrogen load has declined since the late 1980s, which likely related to control measures on atmospheric deposition and wastewater discharge. By contrast, sediment and particulate nutrients have increased since the mid-1990s, which were largely due to diminished trapping in Conowingo Reservoir on Susquehanna River. Substantial rises in sediment and particulate nutrients were also observed, however, in other rivers. Dissolved nutrient loads have declined in the upland (Piedmont-and-above) rivers, but increased in two small rivers in the Coastal Plain that are affected by lagged groundwater input. Finally, TN:TP ratios have declined in most rivers, suggesting the potential for changes in nutrient limitation. Overall, this integrated study of historical data highlights the value of maintaining high quality monitoring at multiple locations in the watershed. *Keywords: Trend analysis, Nutrients, Modeling, Watersheds, Water quality, Management.*

ZHANG, T.Q., TAN, C.S., WANG, Y.T., and WELACKY, T., Harrow Research and Development Center, Agriculture and Agri-Food Canada, 2585 County Rd. 20 E, Harrow, ON, N0R 1G0, CANADA. **Use of soil legacy P, a valid approach meeting 40% loading reduction goal in the Lake Erie basin?**

Legacy phosphorus (P) in agricultural lands has been deemed the major source contributing to eutrophication of the Lake Erie. Canada and USA bilateral governments have set up a goal of 40% P loading reduction by 2025. Soil P draw-down (PDD) is a potential beneficial management practice for high P soils to overcome legacy P effect and mitigate soil P loss. A field experiment was conducted to assess the effects of PDD on crop yields, soil test P change, and soil P losses in both surface runoff and tile drainage under a corn-soybean rotation in a Brookston clay loam soil in a 9-year period from 2008 to 2016. Both yields of corn and soybean with PDD were highly identical to those with continuous P addition (CPA). Soil Olsen P with PDD declined with time at about 2.3 mg P kg-1 year-1, while with CPA it remained unchanged. Relative to CPA, PDD significantly decreased dissolved P and particular P losses, eventually the total P loss by 36%. In addition, farmers' production profitability increased by 15% through savings in investment for P fertilizer. The results indicate that utilization of soil legacy P can be an effective approach that enables us to reach the agri-P loading reduction goal, while improving production profitability and conserving world P resource. *Keywords: Phosphorus, Lake Erie, Management.*

ZHENG, Y.[1], BOOSTRA, R.[1], WILSON, C.[2], and MANDRAK, N.E.[1], [1]University of Toronto Scarborough Campus, Toronto, ON, CANADA; [2]Ministry of Natural Resources and Forestry, Peterborough, ON, CANADA. **Measuring thermal stress and tolerance of Brook Trout under chronic temperature exposure.**

Brook Trout (*Salvelinus fontinalis*) have been in decline in the Greater Toronto Area (GTA) since the late 1800s. Today, its range has shrunk towards the headwaters as multiple stressors continue to threaten existing populations. Development is now occurring in areas of historical Brook Trout habitat in GTA headwaters. As stream water temperatures climb due to climate change and urban development, coldwater species such as Brook Trout are the most severely impacted. To test the ability of Brook Trout to adapt to changing temperature conditions, yearlings were raised under three different temperature treatments (13,17,21°C) for a month, then returned to ambient waters for another month. Every two weeks during this experiment, physiological samples were taken (blood glucose, plasma cortisol, hematocrit, blood smears) and the fish were challenged to a Critical Thermal Maximum protocol. We hypothesize that there will be differences in the physiology and thermal tolerance of fish raised in different temperatures, and that the effects will be measurable for some time after fish are returned to ambient conditions. These results will provide an indication of the extent to which Brook Trout will be able to adapt to changes to its thermal habitat and identify possible physiological markers for monitoring purposes. *Keywords: CTMax, Thermal stress, Trout.*

ZHOU, C. and JIAO, Y., Virginia Tech, Blacksburg, VA, 24060, USA. **Bayesian modeling of uncertainty in the natural mortality of statistical catch-at-age models.**

Temporal variation in the natural mortality component is commonly ignored in fishery stock assessment models. Nonetheless, natural mortality bears important consequences in the stock status and fishery management. The high level of uncertainty in the parameter estimation of natural mortality inside statistical catch-at-age, SCA, models is a common concern, but rarely has a SCA model explicitly models such uncertainties, instead a fixed natural mortality estimated externally is often used. In this paper, we model such variation in the natural mortality component of SCA models, both in time and age classes, using Lake Erie walleye population as an example. Results show the substantial amount of variation in the natural mortality component of the Lake Erie walleye SCA models. We recommend explicitly modeling the variability of the natural mortality component inside SCA models, e.g., using a hierarchical structure over time, to implicitly account for those variations. *Keywords: Time series, Lake Erie, Natural mortality, Walleye.*

ZHOU, C.L.[1], ZHOU, H.A.[2], JOHNSON, T.A.[2], CRIMMINS, B.S.[1], HOPKE, P.K.[1], COHEN, M.[3], and HOLSEN, T.M.[1], [1]Department of Civil and Environmental Engineering, Postdam, USA; [2]Institute for a Sustainable Environment, Potsdam, USA; [3]Air Resources Laboratory, U.S. National Oceanic and Atmospheric Administration, Washington D.C., USA. **Mercury temporal trends in top predator fish of the Laurentian Great Lakes from 2004 to 2015: are.**

Mercury (Hg) concentration trends from 2004 to 2015 in top predator fish (lake trout and walleye) of the Great Lakes (GL) were determined by Kendall-Theil robust regression with a cluster-based age normalization method. A significant decreasing trend in overall lake trout Hg concentrations was found between 2004 and 2015 with an annual decrease of -4.1% per year, consistent with the decline in regional atmospheric Hg emissions. However, a breakpoint was detected with a more significant decreasing slope (-8.1% per year) before the breakpoint (2004~2010) and no trend after the breakpoint. When

the lakes are examined individually Lakes Superior and Huron, which are dominated by atmospheric Hg inputs and are more likely to respond to the decline in regional emissions, were found to have clear decreasing trends with rates between 5.2% and 7.8% per year; Lakes Michigan, Erie, and Ontario, which are dominated by watershed-derived and local industrial sources and are more likely to respond to the local Hg emissions, were found to have decreasing then non-decreasing or increasing trends. These results indicate that the response to decreasing regional atmospheric Hg emission trends can be counterbalanced by other factors including increasing local emissions, eutrophication, and responses to global climate change. *Keywords: Mercury, Trends, Trout, Climate change.*

ZHOU, C.L.[1], CRIMMINS, B.S.[1], PAGANO, J.J.[2], and HOLSEN, T.M.[1], [1]Clarkson University, Potsdam, NY, 13676, USA; [2]State University of New York at Oswego, Oswego, NY, 13126, USA. **Polybrominated Diphenyl Ethers (PBDEs) in Great Lakes Lake Trout: -Are Degradation Product Concentra.**

Polybrominated diphenyl ethers (PBDEs) were developed as effective flame retardants and were widely used after the 1970s. Since that time it has been determined that they are endocrine disruptors and are associated with neurotoxicological effects. PBDEs are currently found widely in the environment including in fish, birds and the human body. Their use has been voluntarily phased out beginning in 2004 and totally phased out at the end of 2013 in the U.S. This work is a part of Great Lakes Fish Monitoring and Surveillance Program (GLFMSP), which collects lake trout and walleye samples (of similar size) at two sites from each of the Great Lakes in alternate years. Five major and 21 other PBDE congeners were analyzed in different years along with fish age. The PBDEs trends were determined using Sen's slope after age normalization. Decreasing trends of PDBE 47, 99 and 153 were found in lakes Huron, Michigan, Ontario and Superior; the concentration of decaPBDE has also declined in recent years. PBDE 100 and 154, which can be produced from the degradation of decaBDE, have "V" shaped trends with breakpoints around 2008 in most lakes indicating the degradation of decaBDE may be having an impact on fish bio-accumulation and trends for these congeners. *Keywords: Age normalization, Lake trout, Trends, PBDEs, Monitoring.*

ZHOU, H.[1], WU, S.[2], KONG, D.[2], FAN, Y.[2], LI, X.[3], and BELETSKY, D.[1], [1]University of Michigan, 500 S. State Street, Ann Arbor, MI, 48109, USA; [2]Yunnan Institute of Environmental Science, Qixiang Road, Kunming, 650034, CHINA; [3]Yunnan Normal University, Yuhuapianqu 1, Kunming, 650500, CHINA. **A Discussion of Arsenic Pollution Control with Ferric Chloride in Yangzong Lake of Southwest China.**

Under the public pressure aroused by a severe arsenic pollution event in 2008, more than six thousand tons of ferric chloride had been dosed into Yangzong Lake (YL), and arsenic concentration decreased from 0.11mg/L to 0.006mg/L. However, monthly monitoring showed a recent increase of arsenic concentration in YL with the arsenic concentration currently fluctuating around 0.05mg/L, the threshold of Class IV for the surface water standard in China. Since the local population is highly sensitive to arsenic pollution, a proposal was presented to dose ferric chloride again on a whole-lake scale to further decrease arsenic concentration. In this presentation, ecological risk and necessity of dosing ferric chloride into YL are discussed. It suggested that a second dosing of ferric chloride would add excessive ferric chloride to water body, while the ecological risk remained unknown. Various factors and consideration for ecological functioning of the basin as a whole should be taken into account in decision making. *Keywords: Decision making, Cleanup, Arsenic, Pollutants.*

ZHOU, H.A.[1], ZHOU, C.L.[2], LYNAM, M.M.[3], DVONCH, J.T.[3], BARRES, J.A.[3], HOPKE, P.K.[1], COHEN, M.[4], and HOLSEN, T.M.[2], [1]Institute for a Sustainable Environment, Clarkson University, Potsdam, NY, 13676, USA; [2]Department of Civil and Environmental Engineering, Clarkson University, Potsdam, NY, 13676, USA; [3]University of Michigan Air Quality Laboratory, Ann Arbor, MI, 48109, USA; [4]Air Resources Laboratory, U.S. National Oceanic and Atmospheric Administration, College Park, MD, 20740, USA. **Atmospheric Mercury Temporal Trends Downwind of the Great Lake from 1992 to 2014.**

Long term atmospheric mercury measurements at Underhill, VT (VT99) and Huntington Forest, NY (NY20) from 1992 to 2014 and 2005 to 2014, respectively to determine concentration trends using the Mann-Kendall's tau test with Sen's slope estimator. Data from these sites, generally downwind of the Great Lakes and large Hg sources in the Midwestern U.S. At VT99 concentrations of gaseous element mercury (GEM), gaseous oxidized mercury (GOM) and particle-bound mercury (PBM) declined with rates of -1.8%, -3.2% and -6.7% per year, respectively. At NY20 GEM and GOM concentrations declined with rates of -1.6% and -7.8% per year. However, PBM concentrations increased at a rate of 2.0% per year likely related to wood combustion. A trajectory ensemble analysis using potential source contribution function indicates the source locations associated with high mercury concentration changed from the Toronto-Buffalo and Pennsylvania areas to east-coast. The declining GEM concentrations in the downwind area of Great Lake are positively correlated with decreasing SO2 emissions in the upwind area. Overall, the results indicate that decreased mercury concentrations measured during the past decade are consistent with decreased Hg emissions from regional point sources and that increasing global emissions have not overwhelmed those decreases *Keywords: Atmospheric circulation, Trends, PSCF, Monitoring.*

ZHU, G.W., Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences, 73 East Beijing Road, Nanjing, JS, 210008, CHINA. **Challenge of extreme weather on cyanobacterial bloom control in Lake Taihu, China.**

Lake Taihu, the third largest freshwater lake of China, suffered from extreme Microcystis bloom for more than 30 years. The bloom threaten the drinking water supply function for Wuxi and Suzhou, two cities with population of around 10 million. After 2007, plenty of restoration projects has been applied in Taihu catchment, however, the restoration processes is very slow, phosphorus concentration in lake water still high. The challenges for N and P reduction in Lake Taihu include sediment resuspension, bloom-related ecosystem feedbacks, and also episodic, extreme climate events. Based on long-term nutrient monitoring, the challenges of nutrient reduction in Lake Taihu have been analyzed. Both N and P concentration in Taihu were strongly influenced by external inputs. Extreme storms and strong wind disturbances will have large effects on N and P concentrations, which influence cyanobacterial bloom patterns in the lake. For long-term bloom control, additional N and P reductions from agriculture, wastewater discharge, and enhancing the buffering and removal capacity of wetlands, streams and and rivers in the catchment are needed.
Keywords: Shallow lake, Drinking water, Bloom, Climate change, Microcystis.

ZORN, T.G.[1] and ZORN, S.A.[2], [1]Michigan DNR- Marquette Fisheries Research Station, 484 Cherry Creek Road, Marquette, MI, 49855, USA; [2]American Fisheries Society (Taylor and Francis), 855 Lakewood Lane, Marquette, MI, 49855, USA. **Hydrologic influences on fish and Jim Diana's influence on two biologists.**

Over 20 years ago, Jim Diana took on two graduate students to work on what were somewhat new research areas for him. One project assessed the relationship between stream habitat availability and fish density, evaluating a critical assumption of an instream flow modeling approach that was commonly used for allocating streamflows. The other project sought to better understand factors limiting reproductive success of muskellunge in Wisconsin lakes. Both projects produced results useful to fisheries managers, and set the stage for additional research and analysis. Jim's influence through this work benefited muskellunge and stream fish populations in the Great Lakes region and beyond. We continue to receive long-term professional and personal benefits from Jim's efforts, and are grateful for his influence on our lives. *Keywords: Water level fluctuations, Fish reproduction, Habitats, Fish behavior.*

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