International Association for Great Lakes Research

ABSTRACTS

59th ANNUAL CONFERENCE ON GREAT LAKES RESEARCH

University of Guelph

June 6 - 10

Great Lakes Solutions

Integrating Across Disciplines & Scales

IAGLR

GUELPH, ONTARIO 2016

ABSTRACTS

59th Annual Conference on Great Lakes Research

June 6–10, 2016
University of Guelph

International Association for Great Lakes Research
4890 South State Road
Ann Arbor, Michigan 48108

Cover design and conference logo by Jenifer Thomas

CONTENTS

ABSTRACTS

An alphabetical listing of abstracts presented at the 58th Annual Conference on Great Lakes Research, organized by first author. Presenters are underlined.

A

ABEBE, F.[1], RIOS MENDOZA, L.M.[1], and DUHAIME, M.B.[2], [1]University of Wisconsin Superior, Belknap and Catlin, Superior, WI, 54880; [2]University of Michigan, Kraus Natural Sciences, N. University, Ann Arbor, MI, 48109. **Persistent Organic Pollutants on Microplastic Debris from Great Lakes.**

Microplastic pollution is becoming a fast growing problem in our environment. Our society is highly dependent on plastic products; from large industrial goods to the smallest plastic bags one gets from the stores, can all be potential hazards to the environment if they are not disposed properly. These products are not being recycled properly and they are polluting different water bodies and also other natural environments. Microplastic pollution can be highly catastrophic to the aquatic organisms because of the known potential to adsorb persistent organic pollutants, POPs, which can affect the human race. The problem is not being emphasized as it should be compared to its disastrous impact. The objective of this research is to provide an assessment of the pollution caused by microplastic debris in the Great Lakes waters by adsorption of toxic compounds. The preliminary results presented are from 44 samples from surface water (33 samples) and sediments (11 samples) collected from May to August, 2014. The plastic debris collected was classified by color, size, and chemical composition of the synthetic polymer. *Keywords: Microplastics, POPs, PCBs, Freshwater, PAHs.*

ALAKAYAK, W.M.[1], SOKOL, E.C.[2], and URBAN, N.R.[2], [1]Keweenaw Bay Ojibwa Community College, 111 Beartown Rd., Baraga, MI, 49908; [2]Michigan Technological University, 1400 Townsend Dr., Houghton, MI, 49931. **Lake Characteristics that Affect Biomagnification of Mercury in Michigan's Upper Peninsula.**

Food webs in the Lake Superior watershed are impacted by the atmospheric deposition of mercury. Torch Lake, an inland lake connected to Lake Superior suffers from high concentrations of mercury leading to fish consumption advisories that affect members of the Keweenaw Bay Indian Community who use it as a traditional spear fishing site. This poster examines factors that influence the bioaccumulation of mercury in lake food webs; we focus here on fish community as a surrogate for food web structure. Using existing data for multiple lakes in the western Upper Peninsula, we developed an empirical relationship between lake characteristics and lake fish communities. We measured biological components of Torch Lake and compared these to the empirical model to test its ability to predict fish communities in lakes for which the model was not calibrated. This is one step towards building a model that can help predict mercury concentrations in other settings. As numerous lakes across the region have similar problems with mercury contamination, our findings will help local residents determine how much fish can be consumed safely. *Keywords: Mercury, Bioaccumulation, Food chains.*

ALARCON, M.A. and MAIGRET, J., Taubman College of Architecture & Urban Planning, University of Michigan, Ann Arbor, MI. **Visualizing the Dynamic Shorelines of the Great Lakes.**

The shoreline landscapes of the Great Lakes are dynamic natural systems and an important part of the culture, economy, and ecology of the coastal communities in the region. Yet our desire to inhabit the shore also yields conflict between the built environment and the physical realities of coastal dynamics. The conservation, enjoyment and development of the shoreline over time have triggered a series of planning efforts aimed to sustainably manage these resources. This talk integrates research informed by urban planning, coastal engineering, landscape architecture and law through the use of visualization techniques. The project employs computational analysis, spatial modeling and graphic visualization techniques to enhance our understanding of the complex dynamics of Great Lakes shorelines. Through the selection of specific coastal sites, the work explores different techniques of visualization to gain knowledge of a physical and ecological system that fluctuates over space and time, and question current regulatory mechanisms defining water levels and development. These digital technologies sponsor collaborative conversations between urban planners, coastal engineers, state policy makers, architects, land owners, and local public officials to find a common language for making informed shoreland management decisions. *Keywords: Coastal engineering, Urban watersheds.*

ALIAN, O.M., ALKHAFAJI, H.N., FINE, H.M., VASQUEZ, A.A., SEN, B., and RAM, J.L., Wayne State University, 540 E. Canfield St, Dept of Physiology, Detroit, MI, 48201, USA. **Automated Measurement of Enzymatic Activity for Monitoring Live Organisms in Ballast Water.**

US, Canadian, state, and international regulations will soon require ships entering the Great Lakes to treat ballast water so that virtually no live organisms will be released in discharged ballast water, thereby preventing the introduction of non-native or pathogenic species. The Automated Fluorescence Intensity Detection Device (AFIDD) was developed to differentiate live from dead organisms in ballast water by measuring enzymatic activity that metabolizes fluorescein diacetate (FDA, non-fluorescent) to fluorescein (fluorescent) in live organisms (Akram et al., 2015, Water Research 70:404-413). To increase detection sensitivity, microorganisms (e.g. Ankistrodesmus algae) are captured on 0.2 um filters and backwashed into a reaction chamber with FDA for measurement. The type and mesh size of filters determines the size range of organisms detected and how many measurements can be made with the same filter. The protozoan *Tetrahymena* (typically >10 um in diameter) could be effectively captured and efficiently backwashed into the reaction chamber from a 5 um polycarbonate track-etched (PCTE) filter and measured with FDA at various cell densities. This recent work can assist regulatory decisions on treating and discharging ballast. Supported by the Great Lakes Protection Fund, Project #964. *Keywords: Invasive species, Indicators, Monitoring.*

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.**

Patterns of biodiversity loss are prevalent within Canada. Approximately 30% of Canadian freshwater fishes are at risk. Ontario watersheds are of concern due to their diverse fish communities, productive environments, and threats from numerous anthropogenic stressors (Chu et al. 2015). The Credit River watershed, found in southern Ontario, has approximately 60 fish species and faces stressors including climate change, aquatic invasive species (AIS), and urbanization. This research examines fish community change in the Credit River watershed and the multiple stressors responsible for the change. Historical fish datasets collected in the Credit River watershed from 1954 to present will be used to analyze fish community change. Stressor data will consist of historical climate data (temperature, precipitation), population censuses, road density layers, and AIS. The results of this research will provide immediate information on the current state of fish communities in the Credit River watershed. Emphasis will be placed on changes in species richness and the emergence of novel assemblages (homogenization). The results may also be used to better understand the interactive effects of multiple stressors in freshwater ecosystems and provide insight into effective watershed management in areas with diverse fish communities and stressors. *Keywords: Urban watersheds, Community Change, Credit River, Multiple Stressors, Fish.*

ALLEN, P.W.[1], DEMPSEY, D.A.[2], PENTLAND, R.[3], MAYER, A.[4], and LOBRICHON, S.[1], [1]International Joint Commission, 234 Laureir Ave W., Ottawa, ON, K1P 6K6, CANADA; [2]International Joint Commission, 2000 L St NW, Washington, DC, 20036, USA; [3]Ralbet Entrprises Incorporated, Ottawa, ON, CANADA; [4]Michigan Technological University, Houghton, MI, 49931, USA. **Protecting the Great Lakes from Harmful Withdrawals and Diversions: Progress and Prospects.**

Protecting the waters of the Great Lakes from potentially harmful consumptive uses and diversions is fundamental to the long term economic and ecological sustainability of the Lakes. In 1999, the Canadian and U.S, governments asked the International Joint Commission (IJC) to examine such matters and in 2000 the Commission recommended a number of actions. A recent review of progress found that most of the recommendations have been implemented and that the eight states and two provinces are working collaboratively to manage major withdrawals and consumptive uses in the basin. No new diversions which could have significant negative impacts on Lakes have been approved, the growth in consumptive use appears to have been at least temporarily arrested, and institutional arrangements are in place to continue those positive trends. Additional scientific advances to reduce uncertainty in water balance components, the impacts of climate change, methods for determining cumulative impacts of diversions and consumptive use, and groundwater resource availability, will be required to maintain that positive momentum. An adaptive management approach to managing Great Lakes water resources is recommended and continuing interaction between science advancements and policy development is critical for successful management of the Great Lakes. *Keywords: Environmental policy, Diversions, Great Lakes basin, Consumptive uses, Management, Withdrawals.*

ALLEN, T., JEWSON, J., LIDBETTER, B., and KETTLE, W., University of Guelph, Guelph, CANADA. **Wetland Restoration Design for McLaughlin Bay: A student capstone design.**

McLaughlin Bay is a provincially significant coastal wetland adjacent to Lake Ontario in Oshawa, Ontario. The lands adjacent to the Bay are owned and managed by a number of different entities, including the General Motors Company of Canada (GM). The Bay provides recreational opportunities for fishing, hunting and nature appreciation. However, high turbidity, temperature and salt concentrations contribute to poor water quality. As with other Great Lakes wetlands, the regime of water level fluctuations has been altered. These

conditions have led to increased populations of invasive species and poor habitat for native species. A student capstone design team from the School of Engineering at the University of Guelph, has undertaken a wetland restoration design for GM, focussed on improving water quality and native species habitat. The design solutions include source control, shoreline stabilization, and in-bay measures. Options to restore a hydraulic connection to the lake, through the barrier beach, were also considered. Implementation of the restoration design can improve natural wetland functions and recreational opportunities within the bay. This project aims to set an example for other coastal wetlands facing similar water quality problems. *Keywords: Wetlands, Water quality, Habitats.*

ALLERTON, M.L.[1], GUDIMOV, A.[1], CHENG, V.[1], RICHARDS, A.[2], and ARHONDITSIS, G.B.[1], [1]University of Toronto Scarborough, Department of Physical & Environmental Sciences, 1265 Military Trail, Toronto, ON, M1C 1A4, CANADA; [2]Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6, CANADA. **Bayesian Watershed Modelling to Support Adaptive Management in the Southeastern Georgian Bay Area.**

The embayments of Georgian Bay demonstrate temporal and spatial variability in trophic status depending on tributary phosphorus input, a major driver of algae growth. Our project synthesizes tributary phosphorus data from provincial, municipal, citizen science, and conservation authority monitoring programs and applies the SPARROW watershed model to estimate nutrient yields and deliveries across the entire south-eastern Georgian Bay watershed. We quantify nutrient loading from ungauged subwatersheds, identify "hot spots" where excessive nutrient export occurs, and improve annual loading estimates for the major sub-catchments, including the French, Magnetawan, Muskoka, Severn, and Nottawasaga River watersheds. A unique feature of the project is the application of a Bayesian hierarchical framework for model calibration, which has the ability to accommodate year-to-year variability within the watershed by sequentially updating the model with newly collected data. Our approach is therefore highly relevant to local conservation practices, such as the policy practice of adaptive management implementation, and offers a long-term management tool. *Keywords: Georgian Bay, Bayesian inference, Phosphorus, Adaptive management, Watersheds.*

ALLIS, J., FRY, L., and KOMPOLTOWICZ, K., U.S. Army Corps of Engineers Detroit District Great Lakes Hydraulics and Hydrology Office, Detroit, MI, USA. **Exploring the possibilities: A new scenario-based water level outlook tool.**

During the past year, predictions of a strong El Nino dominated media reporting on climatic conditions. For the Great Lakes basin, outlooks called for warm, dry conditions. While in previous years, the public was asking "what will the cold winters do to water levels?", the new question became "how will El Nino conditions impact Great Lakes water levels over the next year?" Although seasonal water level forecasts provide an indication of future water levels, they do not provide a means by which to communicate the range of potential impacts of specific climatic conditions that may be of interest to the public. Recently, the U.S. Army Corps of Engineers developed a 12-month Water Level Outlook product that provides a depiction of how water levels might respond under specific climatic scenarios of immediate interest. Scenarios are built from Net Basin Supply (NBS) sequences that may occur under specific climatic conditions. Since October of 2015, several outlooks have been published, with scenarios including NBS sequences similar to those seen during previous strong El Nino periods as well as synthetic NBS sequences that could result from warm and wet or warm and dry conditions. In this presentation, we will describe the Water Level Outlook product and provide a brief analysis of some scenarios developed to date. *Keywords: Water level, Outreach.*

ALMEIDA, L.Z., GUFFEY, S.C., KRIEG, T.A., and HÖÖK, T.O., Forestry and Natural Resources Department, Purdue University, 195 Marsteller St., West Lafayette, IN, 47907, USA. **Do Yellow Perch *Perca flavescens* Egg Skeins Deter Predation?**

Yellow perch *Perca flavescens* produce a gelatinous egg matrix, or skein, which may provide a variety of protective benefits to their eggs, including deterring egg predators. This study assessed the ability of the egg skein to deter two common egg predators, round goby *Neogobius melanostomus* and calico crayfish *Orconectes immunis*, and attempted to identify the molecular compounds within the gelatinous skein that may facilitate this protection. When predators were placed in an aquarium with multiple prey options, the skein was almost always effective in deterring predation: round goby attempted to bite the eggs in the skein but immediately spit them out, and crayfish struggled to remove the eggs from the skein, eventually abandoning the effort. Further experiments demonstrated that crayfish may develop a learned response to the egg skein, reducing the amount of time spent damaging the eggs. Non-targeted proteomics and metabolomics profiling demonstrated a variety of proteins and non-protein compounds that may be responsible for the protection (e.g., toxic or repulsive proteins and alkaloids), but the active compound(s) have yet to be determined. The responses of round goby and crayfish suggest that the defensive effect of yellow perch skeins may arise through both chemical and mechanical means. *Keywords: Round goby, Defense, Yellow perch, Egg ribbon, Predation, Biomaterial.*

ALOYSIUS, N.R., MARTIN, J., and LUDSIN, S.A., Ohio State University, 590 Woody Hayes Drive, Columbus, OH, 43210, USA. **Changing characteristics of precipitation and its impact on nutrient delivery to Lake Erie.**

Harmful algal blooms are proliferating in Lake Erie due to enhanced nutrient deliveries from upstream watersheds. Human-driven changes in land management, and increasing precipitation and frequency of storms have been identified as key drivers that exacerbate blooms. While total nutrient delivery to the lake and its variability are well-studied, the spatiotemporal dynamics within the contributing watersheds have not been adequately investigated. Identifying areas that are prone to excessive nutrient contributions would be helpful for planners to develop effective management plans. Here we use a hydrological model of Lake Erie's largest watershed and statistical analysis to examine linkages between changes in nutrient dynamics and changes in precipitation characteristics. With the validation of model simulations at multiple locations within the watershed, we are able to sufficiently describe the seasonal, inter-annual and spatial variability of nutrient fluxes. Initial results show that areas with poorly-drained soils respond fast and contribute greater proportions of nutrient fluxes through multiple flow pathways. Our findings highlight the importance of including precipitation characteristics to identify high-risk areas when developing policy and management recommendations for nutrient load reduction under changing climate. *Keywords: Phosphorus, Hydrologic cycle, Climates, Water quality.*

AMELI, A.A. and CREED, I.F., Department of Biology, University of Western Ontario, London, ON, N6A 5B7, CANADA. **Assessment the Appropriateness of Best Management Practices in Controlling Eutrophication.**

Substantial effort has been devoted to the analysis of causal links of eutrophication events and subsequent consequences in aquatic ecosystems. We now know that excessive nutrient loads to regional surface water bodies result in production of harmful algae blooms and hypoxic water leading to increased water treatment costs, health implications, fish kills and declined fisheries. Climatic change may exacerbate these negative impacts and increases phosphorous loads toward water resources. Engineered best management practices such as engineered wetlands and vegetation buffer strips can reduce discharging of excessive nutrient loads to regional surface water resources and mitigate consequences of these eutrophication events. However, little research has been applied to assessing the effectiveness of these management practices in controlling eutrophication and harmful algal blooms. Here, we will apply a 3-D physically-based fully-distributed hydrological modeling approach to simulate and predict watershed-scale surface and subsurface hydrological and nutrient transport processes toward the Lake Erie under different climate scenarios and management practices.

Results suggested that the efficiency of management practices can significantly differ depending upon their types, location and time of application as well as climatic condition *Keywords: Computer models, Environmental policy, Wetlands.*

ANDERSON, E.J.[1] and SCHWAB, D.J.[2], [1]NOAA/GLERL, 4840 S. State Rd, Ann Arbor, MI, 48108, USA; [2]University of Michigan, Ann Arbor, MI, 48103, USA. **Contaminant Transport and Flow Exchange in the Straits of Mackinac.**

The Straits of Mackinac are the connecting waterway between Lakes Michigan and Huron and are one of the most dynamic zones in the Great Lakes. Currents in the Straits have been observed to reach 50 and 100 cm/s, oscillating every few days as a result of a Helmholtz mode between the two lakes. As a result of these dynamic conditions, navigation, search and rescue, and contaminant spill response can be severely impacted. In particular, the Straits are home to heavy commercial shipping traffic and to a set of two underwater oil pipelines that traverse from the upper to lower peninsulas of Michigan. In this study, we further investigate the geostrophic exchange flow in the Straits during summer stratification (bi-directional flow) and during winter conditions using observations and the next-generation NOAA Lake Michigan-Huron Operational Forecasting System (LMHOFS). We use model simulations from LMHOFS, based on FVCOM, to drive a set of particle trajectory scenarios to capture the potential impact of a contaminant release in the Straits. Through a series of release scenarios, we gain a probabilistic understanding of impacted coastal zones and transport pathways in Lakes Michigan and Huron. *Keywords: Hydrodynamic model, Lake Michigan, Lake Huron.*

ANNEVILLE, O.[1], DUR, G.[2], RIMET, F.[1], and SOUISSI, S.[2], [1]INRA, 75 Avenue de Corzent, Thonon, 74200, FRANCE; [2]Université de Lille I, Wimereux, 62930, FRANCE. **Plasticity in phytoplankton annual periodicity: an adaptation to long-term environmental changes.**

Phytoplankton communities present seasonal patterns driven by changes in physical factors, grazing pressure and nutrient limitations. Climatic changes, in combination with local phosphorus management policies have caused important modifications of the environmental conditions, which are expected to impact phytoplankton annual periodicity. In this study we used long-term monitoring data of Lake Geneva to test whether annual patterns of phytoplankton seasonal succession present inter-annual variability in relation to those environmental changes. Our approach combined a Bayesian method to identify species assemblages, and wavelet analysis to detect transient dynamics in seasonal periodicity. A decrease in phosphorus concentrations appeared to play a major role in the inter-annual

replacement of species assemblages. Furthermore, the results also exhibited transient dynamics that were most likely induced by changes in Daphnia sp. abundance. Finally, we demonstrated that plasticity in the pattern of phytoplankton seasonal succession played a stabilizing role at the community level. The results suggest that seasonality and inter-annual changes in seasonal dynamics of species assemblages are important components to consider for underlining and explaining long-term variability in phytoplankton community.
Keywords: Phytoplankton, Eutrophication, Zooplankton.

AREND, K.K., Old Woman Creek National Estuarine Research Reserve, 2514 Cleveland, Huron, Oh, 44839, USA. **Long-term water quality monitoring at Old Woman Creek National Estuarine Research Reserve.**

Old Woman Creek National Estuarine Research Reserve (OWC NERR) is located on the southern coast of Lake Erie just west of Cleveland in Huron, OH. OWC NERR has been monitoring coastal wetland water quality for 35 years. In 1995, The NERR System initiated its System-wide Monitoring Program (SWMP) to detect long- and short-term trends in estuarine water quality and some biological parameters. SWMP monitoring at OWC NERR includes the collection of meteorological data at one site and physicochemical water quality data at four sites in 15-minute intervals. Nutrient data are collected at least monthly at four sites. Meteorological and physicochemical data are available in near real time through the NERR System's Centralized Data Management Office. Preliminary and finalized data for all parameters are available for download quarterly or annually. OWC NERR enhancements to SWMP include sub-daily water level and velocity measurements and subdaily to daily nutrient data collection at wetland inflow and outflow sites. SWMP data are being used locally, regionally, and nationally to guide coastal wetland and watershed management for nutrient loading reduction, habitat restoration, and climate change vulnerability.
Keywords: Lake Erie, Water quality, Monitoring.

ARHONDITSIS, G.B., KELLY, K., SHIMODA, Y., ALLERTON, M.L., CAO, X., CHENG, V., GOZUM, Z.J., GUDIMOV, A., JAVED, A., KALUSKAR, S., KIM, D.K., KOBILIRIS, D., NI, F., and VISHA, A., Department of Physical and Environmental Sciences, University of Toronto, Toronto, ON, MIC1A4, CANADA. **Evaluating criteria for the delisting of Beneficial Use Impairments in Great Lakes Areas of Concern.**

The 2012 Great Lakes Water Quality Agreement maintains a focus on 14 Beneficial Use Impairments (BUIs) across the Great Lakes Areas of Concern (AOCs). Previously developed delisting criteria evaluate the current state of BUIs and progress towards AOC restoration, without consistently having a consensus on how delisting criteria should be set,

and how far environmental conditions must shift to be deemed acceptable. Following this motivation, we reviewed the delisting criteria for all 14 BUIs across all 43 AOCs, to examine their impairment status, rationale of the targets set, and the spatio-temporal resolution considered. Uncertainty in the delisting criteria has been ignored, yet is critical to setting and validating achievement of restoration targets. Further, the use of "reference condition" concept is employed to assess progress for many BUIs, yet the choice of reference sites often lacks clear rationale. To fill these gaps, we propose the use of several statistical approaches and modelling tools to evaluate the current delisting criteria and quantify their likelihood of compliance, in order to set acceptable limits for restoration targets. With this research, we offer an insightful and critical analysis of the BUI delisting process, to help guide future development of Great Lakes governance frameworks. *Keywords: Policy making, Delisting criteria, Environmental policy, Uncertainty, Risk assessment, Impaired states.*

ARIFIN, R.R.[1], JAMES, S.C.[3], DE ALWIS PITTS, D.A.[2], HAMLET, A.F.[1], and FERNANDO, H.J.S.[1], [1]University of Notre Dame, 156 Fitzpatrick Hall of Engineering, Notre Dame, IN, 46556, USA; [2]Center for Research Computing, 111 Information Technology Center, Notre Dame, IN, 46556, USA; [3]Baylor University, One Bear Place #97354, Waco, TX, 76798, USA. **Investigating Summer Thermal Stratification in Lake Ontario.**

Summer thermal stratification in Lake Ontario is simulated using the 3D hydrodynamic model Environmental Fluid Dynamics Code (EFDC). Summer temperature differences establish strong vertical density gradients (thermocline) between the epilimnion and hypolimnion. Capturing the stratification and thermocline formation has been a challenge in modeling Great Lakes. Deviating from EFDC's original Mellor-Yamada (1982) vertical mixing scheme, we have implemented an unidimensional vertical model that uses different eddy diffusivity formulations above and below the thermocline (Vincon-Leite, 1991; Vincon-Leite et al., 2014). The model is forced with the hourly meteorological data from weather stations around the lake, flow data for Niagara and St. Lawrence rivers; and lake bathymetry is interpolated on a 2-km grid. The model has 20 vertical layers following sigma vertical coordinates. Sensitivity of the model to vertical layers' spacing is thoroughly investigated. The model has been calibrated for appropriate solar radiation coefficients and horizontal mixing coefficients. Overall the new implemented diffusivity algorithm shows some successes in capturing the thermal stratification with RMSE values between 2-3°C. Calibration of vertical mixing coefficients is under investigation to capture the improved thermal stratification. *Keywords: Lake Ontario, Thermal Stratification, Modeling.*

ARMENIO, P.M., WARNER, D.M., BUNNELL, D.B., EATON, L.A., EPPEHIMER, D.E., and NOWICKI, C.J., U.S. Geological Survey - Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48197, USA. **Round 2 of Lake Michigan CSMI: are biota rolling with the punches?**

Between 1998 and 2010, Lake Michigan experienced declines in phosphorus concentrations, chlorophyll *a*, and forage fish abundance. There was also an expansion of dreissenid mussels into deeper depths. It is likely that all of these factors have influenced the community composition of zooplankton: decreases in cladoceran and cyclopoid copepod zooplankton and an increase in calanoid copepods. As part of the CSMI effort, two transects in northern Lake Michigan (i.e., Frankfort and Sturgeon Bay) were sampled seasonally at three depths (18, 46, and 110 m) in 2010 and 2015 at multiple trophic levels. We used these data to compare the temporal changes in zooplankton, *Mysis*, and pelagic fish. Zooplankton and *Mysis* were collected using a 153 and 1000 μm mesh net from the whole water column, respectively. Pelagic fish abundances were estimated from hydroacoustics and midwater trawls. Our results will reveal whether the changes that occurred up through 2010 continued through 2015 in northern Lake Michigan or if the biomass and community composition of these pelagic food web components has stabilized over the past five years. *Keywords: Lake Michigan, Zooplankton, Fish.*

ARMSTRONG, M.R., SIWULA, P.J., THOMPSON, A.T., and WINTER, C.L., University of Wisconsin-Milwaukee, Milwaukee, WI, USA. **Creating a Budget: Preliminary Measurements of Hydrology in Laguna Bacalar, Mexico.**

Laguna Bacalar is Mexico's second largest natural lake. Cumulative effects from human influence have led to noticeable degradation of this oligotrophic system. Attempts to quantify the degree of decline have been limited without a historical record of hydrologic data. Information collected January 2016 was used to begin creating an initial water budget. Surface water quality was mapped with multiparameter sondes, creating vertical profiles of chlorophyll, conductivity, dissolved oxygen, temperature, and total dissolved solids in three cenotes; Esmerelda, Negro and Cocalita. Grab samples of surface water and underwater springs were collected for isotopic and major ion analyses. Twice-daily tidal fluctuations are exhibited in the lake proper and adjacent wells due to influence from the sea. Additional information on hydraulic conductivity of the aquifer will be obtained by analysis of the phase shift and amplitude differences between lake and groundwater tidal fluctuations. Continued monitoring of water parameters will be necessary for furthering scientific understanding of Laguna Bacalar. Compiled data will provide the information necessary for creating an accurate water budget, quantifying water quality parameters and minimizing future degradation.

ARNEBORG, L.[1], LILJEBLADH, B.[2], BROSTRÖM, G.[1], and WÄNGBERG, S.A.[1], [1]Department of Marine Sciences, University of Gothenburg, Gothenburg, SWEDEN; [2]Department of Earth Sciences, University of Gothenburg, Gothenburg, SWEDEN. **Wind driven Water Exchange between the two main Basins of Lake Vänern.**

Lake Vänern, the third largest lake of Europe, consists of two large water bodies, Lake Dalbo and Lake Värmland, separated by a shallow archipelago with complex topography. Moored hydrographic observations during the fall of 2014 show that the water exchange through the archipelago is dominated by wind driven exchanges with downwind flow in the shallow parts of the archipelago and a stronger return current in the deeper navigation channel. A simple parameterization of the resulting water exchange is proposed that may also be valid for many of the semi-enclose bays and archipelagos surrounding the lake. We also discuss the importance of these water exchanges for the lake ecosystem, the dispersion of nutrients, toxic compounds and pelagic organisms between the water bodies, and the vertical mixing in the lake. *Keywords: Hydrodynamics, Spatial distribution, Water currents.*

ATIEH, M.A., MEHLTRETTER, S.M., GHARABAGHI, B., and RUDRA, R.P., University of Guelph, Stone road, Guelph, ON, L8W3V5, CANADA. **Prediction of Sediment Rating Curve Parameters for Ungauged Basins.**

This study presents integrated artificial neural networks (ANN) models for prediction of sediment rating curve parameters (rating curve coefficient a and rating curve exponent b) for ungauged basins. The ANN models integrate a comprehensive list of input parameters to improve the accuracy achieved; the input parameters used include: soil, land use, topographic, climatic, and hydrometric data sets. The ANN models were trained on the randomly selected 2/3 of the dataset of 94 gauged streams in Ontario, Canada and validated on the remaining 1/3. The developed models have high correlation coefficients of 0.92 and 0.86 for a and b, respectively. The ANN model for the rating coefficient a is directly proportional to rainfall erosivity factor, soil erodibility factor, and apportionment entropy disorder index, whereas it is inversely proportional to vegetation cover and mean annual snowfall. The ANN model for the rating exponent b is directly proportional to mean annual precipitation, the apportionment entropy disorder index, main channel slope, standard deviation of daily discharge, and inversely proportional to the fraction of basin area covered by wetlands and swamps. Sediment rating curves are essential tools for the calculation of sediment load, concentration-duration curve, and concentration-duration-frequency analysis
Keywords: Modeling, Gages, Sediments.

AVLIJAS, S.[1], MANDRAK, N.E.[2], and RICCIARDI, T.[1], [1]McGill University, Montreal, QC, CANADA; [2]University of Toronto Scarborough, Scarborough, CANADA. **Evaluating and predicting impact of Tench (*Tinca tinca*), a globally introduced cyprinid.**

The Tench, *Tinca tinca* has been expanding its range from the Richelieu River upstream to Lake Champlain, and downstream to the St. Lawrence River, at an increasing rate since its initial detection in 1991. The recent high rates of dispersal of Tench, and its expansion towards the Great Lakes system, raise concerns about the potential ecological consequences of this invasion. We are assessing ecological impacts of Tench in the St. Lawrence River through an analysis of diet overlap of Tench with fishes in invaded communities and changes in the composition of those communities following Tench introduction. With the goal of improving our capacity for rapid risk assessment, we will test the predictive ability of morphometric (shape space) analysis - a novel method of explaining and forecasting community-level impact of introduced fishes. Shape space - a proxy for niche space - will be calculated using morphometric data obtained from photographs, for Tench and Round Goby (*Neogobius melanostomus*) in the St. Lawrence River. Data on impacts of these invaders across sites will be correlated with the relative size and position of the shape space they occupy at each site. *Keywords: Invasive species, Impacts, St. Lawrence River.*

AZIZ, T. and VAN CAPPELLEN, P., University of Waterloo, Waterloo, ON, N2L 3G1, CANADA. **Valuation and historical reconstruction of ecosystem services in the Grand River watershed.**

Valuation of ecosystem services can inform watershed management by analysing the financial implications of land use changes. Here, we estimate the economic value of five water-related ecosystem services in the Grand River Watershed, Ontario, Canada. The watershed covers about 7000 km2 of which about 80% is under agriculture. The watershed is undergoing rapid urbanization, with 81% of a population of 960,000 currently living in cities. This study applies an improved framework and methodology for ecosystems services at watershed scale to rationalize estimation for its incorporation into decision making process. It includes the temporal land cover variability in the watershed and subsequent changes in the selected ecosystem services. The five services included in our analysis are water purification, water supply, water regulation, nutrient cycling and carbon sequestration. They are valuated using a methodology based on unit values of the services and land cover in the watershed. Four land use scenarios are considered that correspond to (1) pre-European settlement, (2) the year 1900, (3) the year 2014 and (4) target land use; a future land-use based on the recommendations of Environment Canada for healthy functioning of ecosystem in the watershed. The temporal variation is proportional to the size of ecological footprint. *Keywords: Economic evaluation, Ecosystems, Grand River.*

B

BAKER, D.B., JOHNSON, L.T., and CONFESOR, R.B., Heidelberg University, 310 East Market Street, Tiffin, OH, 44883, USA. **Implications of Phosphorus Stratification for Targeting Dissolved Phosphorus Reduction Programs.**

Dissolved reactive phosphorus (DRP) moves into runoff and tile flow from cropland either through direct dissolution of surface applied fertilizers and manures or from extraction from surficial soils. DRP concentrations associated with soil extraction increase with increasing soil test phosphorus (STP) levels. Broadcast fertilizer applications, crop residue breakdown on the surface and a lack of inversion tillage cause phosphorus (P) stratification in the soil, resulting in higher STP levels in the upper 0-2.5 cm than in the 0-20 cm layer used for fertility management. A study of stratification in 1,700 Sandusky Watershed fields indicated that: 1) surficial STP levels averaged 55% higher those for 0-20 cm cores; 2) there is a poor correlation between 0-2.5 cm STP levels and 0-20 levels; and 3) absolute amounts of stratification are greater in fields in P maintenance range than in fields with higher or lower STP levels. Because 67% of the fields were in the maintenance range while only 10% of the fields were in the no-further-application range, maintenance range fields accounted for 63% of the cumulative risks for DRP runoff while fields in the no-further-application range accounted for 24%. These results underscore the importance of improved management practices for all fields, including those in the maintenance range. *Keywords: Phosphorus, Stratification, Management, Targeting, Pollution sources, BMPs.*

BALLENT, A.M.[1], CORCORAN, P.L.[1], HELM, P.[2], LONGSTAFFE, F.J.[1], and MADDEN, O.[3], [1]Department of Earth Sciences, University of Western Ontario, 1151 Richmond St. N, London, ON, N6A 5B7, CANADA; [2]Environmental Monitoring and Reporting Branch Ontario Ministry of the Environment and Climate Change, 125 Resources Road, Toronto, ON, M9P 3V6, CANADA; [3]Museum Conservation Institute, Smithsonian Institution, 4210 Silver Hill Road, Suitland, MD, 20746, USA. **Microplastic Contaminant Loads in Lake Ontario Sediments with a Focus on Toronto, Canada.**

Contamination of the Great Lakes with microplastics is now recognized and well known in the surrounding community; however, the fate of this contaminant in freshwater systems is not well understood. In this study we show that microplastics, of densities both less and greater than water, are deposited in nearshore, beach and tributary sediments. Our results show that in Lake Ontario, tributaries are transport pathways and depositional zones for microplastics contamination, and that the greatest densities (pieces/gram sediment) are found at tributary mouths and in harboured areas of the coastline. Microplastic particles were found in all of 51 sediment samples, to depths under the sediment surface of at least 15 cm in nearshore environments and at least 30 cm in beach environments. A major component of the microplastics contamination load isolated from tributary and nearshore sediments appears to be industrial waste. Microplastic density within sediments is negatively correlated with water depth, supporting our conclusion that non-buoyant microplastics are not transported to great distance along the lake bottom. Our research suggests that focusing policy changes and pollution prevention programs in the Greater Toronto Area would drastically reduce microplastic loading into Lake Ontario. *Keywords: Microplastics, Lake Ontario, Sediments.*

BANNISTER, A.E.[1], DRAKE, D.A.R.[2], FERA, S.A.[3], HUNT, L.M.[1], and JOHNSON, T.B.[3], [1]Ministry of Natural Resources and Forestry, Center for Northern Forest Ecosystem Research (CNFER), 955 Oliver Road, Thunder Bay, ON, CANADA; [2]University of Toronto Scarborough, 1265 Military Trail, Toronto, On, M1C 1A4, CANADA; [3]Ministry of Natural Resources and Forestry, Glenora Fisheries Station, RR#4, 41 Hatchery Lane, Picton, On, K0K 2T0, CANADA. **Who is fishing the Great Lakes? Identifying risky behaviours in anglers.**

Recreational anglers are important vectors for the transfer of Aquatic Invasive Species (AIS) within Ontario's Great Lakes and other bodies of water. In fact, survey data suggests that one in eight anglers release bait fish after fishing. To assess the severity of this AIS threat, we categorized Ontario's anglers based on their reported preference for fishing in the Great Lakes, Inland lakes, or both (mixed). Mixed anglers pose a particularly high risk for the spread of AIS as they frequently move between lake types. Using confidential demographic data extracted from the 2010 Recreational Fishing Survey (DFO) and a 2004 Angler Diary from the Thunder Bay area, we estimated that Ontario anglers are comprised of 11% mixed anglers and 15 and 74% Great Lakes and inland lake anglers, respectively. We then investigated whether we could identify "risky" mixed anglers from observable traits, such as age and gender. We observed that the typical mixed angler was male (89.5%), and between 57.93 ± 13.52 years of age. Understanding these demographic factors provides insight for managers to encourage behaviours that will reduce the spread of AIS. Similarly, communication targeting specific behaviours by fishers can help to mitigate the intentional and unintentional transfer of AIS. *Keywords: Risk assessment, Invasive species, Fishing.*

BASU, N.B.[2], VAN METER, K.J.[1], ZHANG, X.[1], and SCHIFF, S.L.[1], [1]Department of Earth and Environmental Sciences, 200 University Ave. W., Waterloo, ON, N2L 3G1, CANADA; [2]Department of Civil and Environmental Engineering, 200 University Ave. W., Waterloo, ON, N2L 3G1, CANADA. **A Statistical Approach to Quantifying Nutrient Lag Times in the Grand River Watershed.**

The Grand River, the largest Canadian river feeding Lake Erie, is greatly impacted by agricultural intensification and urbanization, leading to high riverine fluxes of nutrients. In order to understand and mitigate the problem, it is critical to quantify the legacies of these nutrients that develop in agroecosystems, and lag times in their transport. Here, we have developed a 70-year dataset of nutrient inputs and outputs in the Grand River Watershed, and use them to quantify spatial and temporal patterns in legacy accumulation within the catchment. We then compare these spatial maps to riverine nitrogen and phosphorus fluxes at multiple scales. Results demonstrate a clear decoupling between nutrient inputs and outputs that is suggestive of watershed lag times. A statistical approach is used to quantify the lag times as a function of climate and land use change controls over time. Such quantification of legacies and lag times is critical for watershed managers that implement various best management practices to reduce stream nutrient concentrations. *Keywords: Nutrients, Grand River.*

BECHLE, A.J.[1], WU, C.H.[1], KRISTOVICH, D.A.R.[2], ANDERSON, E.J.[3], and SCHWAB, D.J.[4], [1]University of Wisconsin-Madison, 1415 Engineering Drive, Madison, WI, 53706, USA; [2]Climate and Atmospheric Science Section, University of Illinois at Urbana-Champaign, Urbana, IL, USA; [3]Great Lakes Environmental Research Laboratory, Ann Arbor, MI, USA; [4]University of Michigan, Ann Arbor, MI, USA. **Regional Characteristics of Meteotsunamis in the Laurentian Great Lakes.**

Meteotsunamis are water waves that behave similar to seismic tsunamis but are generated by perturbations in atmospheric pressure and wind. In this paper we use water level and weather radar records to characterize regional patterns in meteotsunami magnitude, season, and associated storms in the Laurentian Great Lakes of North America. Significant meteotsunamis occur in all five Great Lakes and each lake has a unique meteotsunami climatology. Meteotsunamis generally occur from the late-spring to mid-summer, with the annual peak time of meteotsunami occurrence negatively correlated with lake bottom slope and water depth. Great Lakes meteotsunamis are associated primarily with linear and complex convective storms, with spatial variations in associated storm type consistent climatological storm occurrence frequency. Across the region, meteotsunami height tends to increase along the major axis of the lake in the downwind direction of storm propagation
Keywords: Waves, Water level fluctuations, Atmosphere-lake interaction.

BEIGZALI, N.[1], ZHAO, Y.M.[2], ACKERMAN, J.D.[3], SCALO, C.[4], and BOEGMAN, L.[1], [1]Environmental Fluid Dynamics Laboratory, Department of Civil Engineering, Queen's University, Kingston, ON, CANADA; [2]Ontario Ministry of Natural Resources, Aquatic Research and Development Section, Wheatley, ON, CANADA; [3]Physical Ecology Laboratory, Department of Integrative Biology, University of Guelph, Guelph, ON, CANADA; [4]School of Mechanical Engineering, Purdue University, West Lafayette, IN, USA. **Numerical simulations of sediment oxygen demand in Lake Erie.**

Fundamental to water quality, dissolved oxygen (DO) plays an integral role in the aquatic habitat in the Great Lakes. In recent decades, increased nutrient loads and climate change have caused the hypolimnion DO to be depleted more rapidly, with negative effects on fish habitat. In this study, we simulate the DO in Lake Erie using the three-dimensional hydrodynamic ELCOM model coupled with the aquatic ecological CAYDEM model. Model results with two sediment oxygen demand (SOD) models are compared, including the default CAEDYM model, which computes SOD from hypolimnion water temperature and DO concentration, and a new calibration-free process based SOD model (Scalo et al. 2013, J. Geophys. Res.), which computes SOD as a transient flux across the diffusive sublayer. For this purpose the models are forced with meteorological data for the period of April to October 2008 and are validated against observations of both DO and SOD. The physical processes causing fluctuations in the SOD are investigated. *Keywords: Hydrodynamic model, Climate change, Lake Erie.*

BEJANKIWAR, R.S.[1], BINGHAM, M.[2], SINHA, S.K.[4], and LUPI, F.[4], [1]International Joint Commission, 100 Ouellette Avenue, 8th Floor, Windsor, ON, N9A 7A2, CANADA; [2]Veritas Economics Consulting, 1851 Evans Road, Cary, NC, 27513, USA; [3]Environmental Consulting & Technology Inc.,, 2200 Commonwealth Blvd, Suite 300, Ann Arbor, MI, 48105, USA; [4]Agricultural, Food, and Resource Economics, Michigan State University, 446 W. Circle, Dr., Rm 301B, Morrill Hall of Agriculture, East Lansing, MI, 48824-1039, USA. **Economic Benefits of Reducing Harmful Algal Blooms in Western Lake Erie.**

In 2014 International Joint Commission sponsored a study to better understand the socio-economic and policy implications of Harmful Algal Blooms (HABs) in western Lake Erie. In this study, several standard methods were adopted to assess the economic impact on residential property values, recreation, tourism, commercial water use and water. The study's geographical scope included both, the Canadian and American portions of the western Lake Erie. Rather than assessing the actual damages of the 2011 or 2014 events, the study assumed that remedial investments, such as investments protecting water supplies put in place after those events were sufficient to protect drinking water in the future. The study estimated that the annual cost of a reoccurrence of the 2011 HAB event would be approximately $71 million. And if the 2011 event was to recur annually over a period of 30-

years, the business-as-usual scenario, the present value of lost benefits would be $1.463 billion (this estimate uses a 3% discount rate). A similar analyses for the 2014 HAB event indicated that the total cost of ecosystem service interruptions was roughly $65 million, and if that event were to recur over 30-years, its present value is $1.339 Billion.Cost estimates such as these provide a framework to assess remedial measures, this study is among the first. *Keywords: Drinking water, Lake Erie, Algae, Economic impact.*

BENOY, G.A.[1], JENKINSON, R.W.[1], ROBERTSON, D.M.[2], SAAD, D.A.[2], VOUK, I.[3], and RICHARDS, A.[4], [1]International Joint Commission, Ottawa, ON, CANADA; [2]United States Geological Survey, Madison, WI, USA; [3]National Research Council of Canada, Ottawa, ON, CANADA; [4]Environment and Climate Change Canada, Burlington, ON, CANADA. **Binational SPARROW Modelling to Address Water Quality Issues in Transboundary Basins.**

Across North America, lakes and rivers straddle major sections of the Canada-United States (US) border. Many of these systems, such as Lake Erie, suffer from symptoms of eutrophication, including harmful algal blooms and hypoxia, due to excessive loading of nitrogen and phosphorus. In an effort to understand and predict water quality dynamics in transboundary basins, the International Joint Commission (IJC) launched a binational modelling project through its International Watersheds Initiative (IWI). The US Geological Survey (USGS) SPARROW (SPAtially-Referenced Regressions On Watershed attributes) model is being used to relate observed long-term nutrient loads to nutrient sources and land-to-water delivery processes. Following successful application of SPARROW in the Red-Assiniboine River Basin, it is now being applied to the Great Lakes Basin, the Rainy-Lake of the Woods Basin and the Midcontinental Area as a whole. Output from the models will be used in watershed management planning, to identify regions of high nutrient contribution, to estimate changes in nutrient loading due to land use change and climate change, and to assist with the development of water quality objectives. *Keywords: Water quality, Modeling, Nutrients.*

BEUGLY, J.S.[1], FOLEY, C.J.[1], ARCHER, A.S.[1], TROY, C.D.[2], VERHAMME, E.M.[3], and HÖÖK, T.O.[1], [1]Purdue University Department of Forestry and Natural Resources, 195 Marsteller Street, West Lafayette, IN, 47907, USA; [2]Purdue University Lyles School of Civil Engineering, 550 Stadium Mall Drive, West Lafayette, IN, 47907, USA; [3]LimnoTech, 501 Avis Drive, Ann Arbor, MI, 48108, USA. **Targeting audiences for buoy data: a case study in southern Lake Michigan.**

Real-time monitoring data are useful to a variety of stakeholders, ranging from recreational boaters to weather service professionals. Presenting data in a useful and usable format is crucial to ensuring successful transfer of information and continued interest in real-

time observations. In this talk, we will discuss strategies used to target and engage multiple audiences around the southern basin of Lake Michigan. This region is teeming with real-time monitoring buoys and is home to the densest population centers in all of the Laurentian Great Lakes. We will consider factors such as geographic scope of data presentation, ability to view data on different devices, and suitability of means of connecting with different target audiences (e.g., webinars, trade shows) in our discussion, and will include lessons learned over our collective 25 years of managing real-time monitoring assets. *Keywords: Buoys, Lake Michigan, Outreach.*

BEVACQUA, F.L., COLE-MISCH, S.A., and HEISLER, N.J., International Joint Commission, 100 Ouellette Avenue, Suite 800, Windsor, ON, N9A 6T3, CANADA. **IJC to Provide Link between Great Lakes Science and the Public.**

Under Article 7 of the Great Lakes Water Quality Agreement, the International Joint Commission is required to collect scientific and other information to assess progress, and to engage with the public to increase awareness of the inherent value of the Great Lakes and the benefit of taking individual and collection action to restore and protect them. Key to accomplishing these responsibilities is an effective communications strategy that outlines goals and messages, targets partners and audiences, and distributes products with measurable outcomes. Its communications team researched effective communications strategies and interviewed members of universities and colleges with significant Great Lakes research programs, and a variety of Great Lakes organizations representing nature, sports, governments, industry and agriculture, to identify the essential niche the IJC can hold in Great Lakes communications. Results included that because the Commission already provides highly credible scientific findings and recommendations and has the ability to obtain credible information from a variety of sources, the IJC is well positioned to provide this essential link between the research community and the public. Join us to discuss how you can link with the IJC to communicate Great Lakes science and further Great Lakes restoration efforts. *Keywords: Public education, Linkages, Outreach, Science, Public participation, Public.*

BIASTOCH, R.G., CROFT-WHITE, M., JARVIE, S., and ST. JOHN, M., Toronto Region Conservation Authority, Toronto, ON, M3N 1S4, CANADA. **Assessment of Degradation of Aesthetics as a Beneficial Use in the Toronto Area of Concern.**

The 1989 the Toronto Remedial Action Plan (RAP) Stage 1 report, 'Environmental Conditions and Problem Definition' stated that Beneficial Use Impairment #11, Degradation of Aesthetics, was significant to the region as 'aesthetics concerns relate

primarily to debris and litter. Turbidity is also a concern near river mouths and in the vicinity of lakefilling operations. Weed growth is a concern along the western shoreline'. Degradation of aesthetics was thus listed as a BUI, however little monitoring was undertaken to specifically address this BUI as it was seen as challenging to assess in a quantifiable manner. In 2012 the Toronto and Region RAP developed a quantifiable checklist for assessing the Degradation of Aesthetics in the region, technicians at the Toronto and Region Conservation Authority were trained in the assessment and hundreds of sites were sampled throughout the Area of Concern's six watersheds and along the waterfront. The results suggest that Degradation of Aesthetics is no longer a Beneficial Use Impairment for the Toronto and Region Area of Concern and should be reclassified as 'not impaired'.
Keywords: Beneficial Use Impairment assessment, Remedial Action Plan, Toronto.

BIESINGER, Z.[1], GORSKY, D.[1], BRUESTLE, E.[2], and KARBOSKI, C.T.[1], [1]US Fish and Wildlife Service, 1101 Casey Road, Basom, NY, 14103, USA; [2]SUNY Buffalo State, 1300 Elmwood AVe, Buffalo, NY, 14222, USA. **Lake Sturgeon Seasonal and Spawning Habitat Use in the Lower Niagara River.**

Historically, Lake Sturgeon was an abundant species throughout the Great Lakes. Among other factors, loss of access to quality spawning habitat is thought to have contributed to population declines and extirpation in many spawning rivers by the early 20th century. In spite of long protections, sturgeon populations remain less than 1% of historical levels, suggesting poor spawning success or recruitment. The lower Niagara River is home to one of the few remaining populations of Lake Sturgeon in Lake Ontario, where they are officially listed as "threatened" by New York State and the Province of Ontario. Preferred spawning habitat is typically clean, coarse rubble in fast flowing water, a habitat found in the Niagara River Gorge. To describe seasonal and spawning habitat use we tagged 57 Lake Sturgeon with acoustic transmitters to recorded their location and depth in the lower Niagara River from spring 2014 to fall 2015. We describe seasonal movement between the river and the lake, including into suspected spawning areas during the spring spawning season. *Keywords: Niagara River, Great Lakes Restoration Initiative (GLRI), Fish behavior, Lake Sturgeon.*

BILLMIRE, M.G., BROOKS, C.N., SHUCHMAN, R.A., SAYERS, M., GRIMM, A.G., and SAWTELL, R., Michigan Technological University, Michigan Tech Research Institute, 3600 Green Ct., Ste. 100, Ann Arbor, MI, 48105, USA. **Sharing Great Lakes remote sensing data through integrated web portals.**

A larger number of remote sensing products derived from satellite, aerial, and other platforms has become available for the Great Lakes region in recent year. The Michigan Tech Research Institute has been working with the Great Lakes Observing System (GLOS), the NOAA Great Lakes Environmental Research Lab, and other sponsors to make it easier for scientists, the public, agencies, and other stakeholders to visualize and access these products. The Great Lakes Data Portal, myGLOS, Great Lakes Coastwach, and the MTRI Water Remote Sensing site are all web portals that can integrate and display remote sensing data for the region. MTRI-created data sets such as lake-specific chlorophyll, dissolved organic carbon, suspended minerals, and harmful algal bloom maps have been made accessible and are being shared through more of these sites, including through web mapping services to provide a common, authoritative source for the data. *Keywords: Remote sensing, Outreach, Observing systems.*

BIRCEANU, O. and WILKIE, M.P., Wilfrid Laurier University, 75 University Avenue West, Waterloo, ON, N2L 3C5, CANADA. **Effects of Routine Lampricide Treatments on Stress Response in a Non-Target Fish, the Rainbow Trout.**

The lampricide TFM has been used for over 50 years to control sea lamprey populations in the Great Lakes, at doses below lethal thresholds for non-target species. However, little is known about the effects of routine treatments on the stress axis in fish. We investigated whether TFM induces physiological and molecular changes in the stress response pathway of rainbow trout. Juveniles were exposed to the LC99.9 of the sea lamprey for 9 h, after which they were allowed to recover overnight in clean water. Next day, one group was subjected to a chasing stressor, while another, unstressed group, was used for *in vitro* challenges of the head kidney with adrenocorticotropic hormone (ACTH) and 8-bromocyclic-AMP. TFM-exposed fish in the stressed group had higher resting cortisol and lower liver glycogen levels than controls. Cortisol remained elevated in the TFM group even at 48 h post-treatment. The steroidogenic gene profile in their head kidneys was altered, but the metabolic capacity of the liver remained unchanged. The *in vitro* challenges showed no overall treatment effect on the head kidney cortisol production. Therefore, routine TFM treatments have minimal effects on stress response in trout, but they may affect cortisol breakdown, leading to high cortisol levels post-treatment. *Keywords: Endocrine disruption, Stress physiology, Fish populations, Lampricide, Pesticides, Invasive species.*

BLANKEN, P.D.[1], SPENCE, C.[2], LENTERS, J.D.[3], GRONEWOLD, A.D.[4], XUE, P.[5], KERKEZ, B.[6], and CUTRELL, G.J.[3], [1]University of Colorado, Boulder, CO, USA; [2]Environment and Climate Change Canada, Saskatoon, SK, CANADA; [3]LimnoTech, Ann

Arbor, MI, USA; [4]NOAA-GLERL, Ann Arbor, MI, USA; [5]Michigan Technological University, Houghton, MI, USA; [6]Univeristy of Michigan, Ann Arbor, MI, USA. **Points on a Map: Spatial Variability in Great Lakes Surface Energy Budgets from GLEN Observations.**

Processes that drive the surface energy balance show tremendous temporal and spatial variation across large water bodies such as the Great Lakes. As a result, the timing and magnitude of events that drive key processes, such as evaporation and sensible heat loss, can also show large variation in timing and magnitude. To address this, continuous direct measurements of the surface energy balance have been made on Lakes Superior, Huron, Michigan, and Erie as part of the Great Lakes Evaporation Network (GLEN). Here, we compare simultaneous, direct measurements of the surface energy balance for each lake. Due to variations in meteorological conditions, ice cover, and water temperature, the behavior in evaporation events is at times completely different in each lake. We describe the causes of the inter-lake variations in the surface energy balance from the perspective of overlying meteorological conditions. Since our observations are limited to an upwind area of ~10 km, the spatial variation we observe demonstrates the need for continued and enhanced over-lake observations to improve and calibrate coupled lake-atmosphere models and remotely sensed observations. *Keywords: Atmosphere-lake interaction, Micrometeorology, Water level fluctuations.*

BOEGMAN, L. and JABBARI, A., Environmental Fluid Dynamics Laboratory, Department of Civil Engineering, Queen's University, Kingston, ON, CANADA. **Evaluation of inertial dissipation and structure function methods within bottom boundary layers.**

Accurate calculation of dissipation of turbulent kinetic energy within the bottom boundary layers (BBL) of coastal oceans is very important since mixing and biogeochemical fluxes are commonly estimated from the rate of dissipation. However, direct measurement of dissipation in the field studies is impractical since it requires the simultaneous measurement of the instantaneous velocity-gradient in the order of Kolmogorov scale. Therefore the dissipation is estimated indirectly. Performing direct numerical and large eddy simulations of turbulent channel flows, this study evaluates two common methods for calculation of dissipation: the inertial dissipation method (IDM) and structure function method (SFM). Application of these methods to field measurements requires empirical constants that are based on the assumptions of steady state, homogeneity, isotropy and Taylor's frozen turbulence hypothesis which are not valid in BBLs due to high anisotropy in this region. Comparison of the dissipation calculated directly from the numerical data, with that from the IDM and SFM shows that usage of the canonical constants can result in considerable error (>50%). Optimal values of the constants from the simulation results

improve the accuracy of dissipation calculations when using the IDM and SFM with field data from geophysical BBL flows. *Keywords: Coastal engineering, Hydrodynamics, Modeling.*

BOLKHARI, H.[2], MULLIGAN, R.P.[1], BOEGMAN, L.[1], and WATT, S.[2], [1]Queen's University, 58 University avenue, Kingston, ON, K7L 3N6, CANADA; [2]CATARAQUI REGION CONSERVATION AUTHORITY, 1641 Perth Road, P.O. Box 160, Glenburnie, ON, K0H 1S0, CANADA. **Delft3D and SWAN simulations of waves and storm surge in the Cataraqui Region of Lake Ontario.**

Wave uprush is a natural hazard that must be determined prior to coastal development. In this study, we examine the accuracy of existing wave runup methodology used by the Cataraqui Region Conservation Authority (CRCA), which is based on analytical calculations developed by the US Army Corps of Engineers. Airborne Light Detection and Ranging (LiDAR) data from 2014 over the Cataraqui Region shoreline is merged with near shore bathymetry to develop detailed wave and water level predictions in eastern Lake Ontario. The waves conditions are examined using the 2D spectral wave model Simulating WAves Nearshore (SWAN) in the Kingston Basin of Lake Ontario during winter storm events, accounting for the complex processes of wave generation, shoaling, refraction, and breaking as the waves propagate toward the shore. The Delft3D hydrodynamic model is coupled with SWAN, to simulate wind-driven storm surge. The model results are used to develop an understanding of wave and surge conditions during storms, and will be used to assess shoreline runup hazards on the Frontenac Islands. Simulations of extreme storm events are computed and applied to develop nearshore wave conditions to guide land use management along the CRCA shoreline. *Keywords: GIS, Waves.*

BOLTON, R.P. and GINN, B.K., Lake Simcoe Region Conservation Authority, Newmarket, ON, L3Y 3W3, CANADA. **Tracking trends in shoreside benthic communities of Lake Simcoe, ON Canada - 2005 to 2015.**

Shoreside ecosystems can make up some of the most verdant, distinct and ecologically rich environments in most freshwater systems. This zone of interaction between land and water is typically defined as regions from 0 to 1 meter in depth and can encompass a distance anywhere from less than 1 meter to several hundred. These expanses often support the majority of species diversity in waterbodies and are also the areas that are most sensitive to changes. Shoreside habitats are susceptible to dramatic variations in nutrient loading through effluent runoff, shoreline or substrate hardening and climatic conditions such as seasonal temperature regimes, ice cover and wave action. The ecological effects of anthropogenic pressures, including the introduction of several invasive species, and climatic variation can be quantified through the study and use of benthic macroinvertebrates as a metric to measure change. Utilizing data from our annual lake monitoring program we are investigating species fluctuations within benthic macroinvertebrate communities to examine the potential significance and consequences of such changes to the ecosystem health of Lake Simcoe. *Keywords: Amphipods, Lake Simcoe, Benthos.*

BONNER, J.S., FULLER, C.B., ISLAM, M.S., KIRKEY, W., and NELSON, R.N., Clarkson University, 8 Clarkson Ave., Potsdam, NY, 13699, USA. **Comprehensive Iterative Adaptive Operational Model for Comprehensive Inland and Coastal Monitoring.**

Water resource stakeholders require integrated data from continuous monitoring programs at sufficient spatial and temporal resolutions to capture the variability of relevant parameters to conduct vital research for the comprehensive understanding of inland and coastal environments. Despite the value of monitoring programs, they are susceptible to budgetary constraints as evidenced in recent years by service interruptions. In the USA, multiple agencies are responsible for independent operation of their respective programs resulting in redundant network costs. The River and Estuary Observatory Network (REON) was designed and deployed end-to-end using a uniform sensor suite to provide water quality and hydrologic data and assessment through a common cyber-infrastructure. REON has established a direct link to the Consortium of Universities for the Advancement of Hydrologic Science, Inc. rendering the data compatible with and available through other observatory networks. The REON model is robust, flexible and transferable to other watersheds. REON was developed using a comprehensive, iterative, adaptive process where upgrades are incorporated into the network through depot-level maintenance at a frequency defined by component duty cycle to maximize network reliability and data quality and reduce operational costs. *Keywords: Water quality, Hydrology, Cyber-infrastructure.*

BOOTSMA, H.A., FILLINGHAM, J.H., TURSCHAK, B., SHEN, C., and LIAO, Q., University of Wisconsin-Milwaukee, Milwaukee, WI, 53204, USA. **Nearshore nutrient cycling, algal production, and trophic structure in Lake Michigan.**

While numerous studies have highlighted the changes in community structure that have occurred in the nearshore zone of Lake Michigan and other Great Lakes over the past two decades, there remains uncertainty about the implications of these changes for critical ecosystem processes, including nutrient cycling and energy flow, at the whole-lake scale. We present a nearshore ecosystem model that quantifies the influence of dreissenids on C and P dynamics and nuisance Cladophora growth in Lake Michigan, and using stable isotope data we show that these changes are having effects on both the nearshore and pelagic food webs. The model underscores the role dreissenids play in promoting Cladophora growth, while the stable isotope data indicate that nearshore benthic algal production is partially offsetting recent losses of energy in the pelagic food web. *Keywords: Cladophora, Benthos, Dreissena.*

BOSTON, T., Greenland Consulting Engineers, 120 Hume Street, Collingwood, ON, L9Y 1V5, CANADA. **Watershed Decision Support Systems: Policy, Planning and Cumulative Effects Assessment Applications.**

Watershed modeling decision support systems (DSS) represent an important tool for decision makers, planners and policy analysts. They allow for consideration of many cumulative effects in one system. Base models help identify existing contributing stressors and level of impairment. Scenario analysis helps to identify potential outcomes from multiple infrastructure, planning and policy options within both the urban and rural context. Recent applications of the CANWET DSS illustrate approaches for setting up and calibrating large, complex models. Models were subsequently used as part of a DSS in target setting, cumulative effects assessment, mitigation strategy development and policy options testing to address watershed stresses. The spatial and temporal aspects of models help prioritize how and where resources are used to address management issues. *Keywords: Watersheds, Modeling, Decision making.*

BOURGEAU-CHAVEZ, L.L., ENDRES, S.L., BROOKS, C.N., GRIMM, A.G., SEROCKI, E., and SCHOLD, E., Michigan Technological University, Michigan Tech Research Institute, 3600 Green Ct., Ste. 100, Ann Arbor, MI, 48105, USA. **Monitoring the effectiveness of *Phragmites australis* treatment for the Great Lakes coastline.**

Millions of dollars have been spent on herbicide and other control measures of the form of the wetland plant Phragmites australis, but few efforts have included monitoring to assess the effectiveness of treatment on habitat restoration and biodiversity. A study was conducted to analyze field and remote sensing data in a nested design to develop recommendations for standardized methods for monitoring treatment success. Through field sampling, paired treated and non-treated Phragmites dominant sites were assessed in Green Bay and Saginaw Bay for biodiversity of birds, amphibians, and vegetation. Aerial and satellite imagery at various scales were used to map treatment success at the landscape scale. Remote sensing data provides the spatial context of the distribution of live Phragmites plants including leading edges, and it also provides documentation of the location of dead Phragmites vegetation regrowth and spatial context with adjacent lands. Field data provide an assessment of the biodiversity of a site and presence of rare or endangered species. Both

field and remote sensing-based monitoring are needed for adaptive management strategies in controlling Phragmites. The main findings of this research, including a comparison of the impacts of treatment efforts in Green Bay and Saginaw Bay, will be presented.
Keywords: Phragmites australis, Monitoring, Remote sensing.

BOWEN, K.L.[1], CONWAY, A.J.[2], and CURRIE, W.J.S.[1], [1]Fisheries and Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7S 1A1, CANADA; [2]Ministry of Natural Resources and Forestry, 1450 Seventh Ave E, Owen Sound, ON, N4K 2Z1, CANADA. **Could *Dreissenid Veligers* be the Lost Biomass of Invaded Lakes?**

The widespread ecological impacts of invading adult zebra and quagga mussels (*Dreissena polymorpha* and *D. bugensis*) is well documented worldwide, but less is known about the ecology and fate of their veliger larvae. Veligers are often unreported in many Great Lakes studies, due to use of coarse mesh gear, or not counted by some programs during taxonomy. It is also unclear if the commonly used length-weight regression equation by Hillbricht-Ilkowska and Stanczykowska (1969) estimated wet or dry weight, and researchers have applied a wide range of correction factors from 10% to 50%. We have developed a new dry weight equation, which yields values approximately 74% of the original equation, and measured the shell contribution by size. Using this new relationship, veliger May to October biomass in nearshore Lake Ontario averaged 9.9 ± 1.7 mg m^{-3}, or 29.0 ± 3.6% of the total zooplankton biomass between 2007 and 2014. Veliger densities have generally increased in eastern Lake Ontario after 2007, likely due to the increasing abundance of adult quagga mussels larger than the gape limit of Round Gobies. Veligers may be consumed by alewife and mysids, but generally the fate of these abundant small herbivorous zooplankton needs further investigation. *Keywords: Lake Ontario, Dreissena, Food chains.*

BOWMAN, M.F.[1], GRAPENTINE, L.C.[2], CIBOROWSKI, J.J.H.[3], JOHNSON, L.B.[4], ALLAN, J.D.[5], and SMITH, S.D.P.[5], [1]Forensecology, Guelph, ON, N1E7J1, CANADA; [2]Environment & Climate Change Canada, Burlington, ON, L7R4A6, CANADA; [3]University of Windsor, Windsor, ON, N9B3P4, CANADA; [4]University of Minnesota Duluth, Duluth, MN, 55811, USA; [5]University of Michigan, Ann Arbor, MI, 48109, USA. **Invertebrate community response to cumulative anthropogenic stress in the Laurentian Great Lakes.**

Relationships between benthic macroinvertebrate (BMI) community composition and cumulative anthropogenic stress were documented using monitoring data collected as part of the Great Lakes Action Plan and stressor gradients defined in the Great Lakes Environmental Assessment and Mapping Project (GLEAM). The objective of the Action Plan was to restore water quality and beneficial uses of the ecosystem by cleaning up Areas of Concern (AOCs) identified as being most degraded. GLEAM estimated the spatial distribution of cumulative stress from aquatic habitat alterations, climate change, coastal development, fisheries management, invasive species and non-point and toxic chemical pollution. As expected, we found that littoral, nearshore and pelagic BMI communities were distinct from one another and changed across gradients in anthropogenic stress. For example, nearshore communities in the Manitoulin-Lake Simcoe Ecoregion changed most distinctly along gradients of warming and phosphorus loading from tributaries. Identifying these biological responses to both individual and cumulative stresses will help guide effective resource management in the Laurentian Great Lakes. *Keywords: Benthos, Cumulative stress.*

BOYD, L.M. and CHOW-FRASER, P., McMaster University, 1280 Main Street West, Hamilton, ON, L8S 4K1, CANADA. **Are current indices appropriate for determining wetland health under water-level disturbances?**

Common indices available to assess health of coastal wetlands target effects of human-induced nutrient or sediment enrichment (e.g. the Water Quality Index (WQI), Wetland Fish Index (WFI) and the Wetland Macrophyte Index (WMI)); however, they do not explicitly account for changes in biotic communities due to natural disturbances such as water levels. The largest threat to coastal wetlands in Georgian Bay has been lack of water-level fluctuations; between 2000 to 2013, Lake Huron experienced an unprecedented period of sustained low water levels, with water levels approaching the long-term mean returning only in 2014 and 2015. Using water quality, plant and fish data from a long-term synoptic monitoring program, we compared WQI, WFI and WMI scores corresponding to years when water levels were high and when they were relatively low, and found no significant differences. This is despite an obvious change in the fish guilds and the plant communities. We discuss how shifts from low to high water levels require different sampling protocols to account for biological community changes during the transitional period. Understanding the disjuncture between commonly used wetland quality indices and the effects of water-level disturbances is crucial to ensure that their potential impacts are not overlooked. *Keywords: Coastal wetlands, Water level, Water level fluctuations.*

BOYER, G.L.[1], PERRI, K.[1], PAVLAC, M.[1], ZASTEPA, A.[2], and WATSON, S.B.[2], [1]State Univeristy of New York, College Environmental Science and Forestry, Department of Chemistry, Syracuse, NY, 13210, USA; [2]Environment and Climate Change Canada, Canadian Center for Inland Waters, Burlington, ON, L7S 1A1, USA. **Harmful Algal Blooms in Lake Ontario: It is More than a Lake Erie Issue.**

Harmful cyanobacterial blooms (cHABs) in Lake Erie have received widespread science and media coverage, but are less well characterized in other Great Lakes. Fewer long-term databases exist to evaluate reports of significant cHABs in the harbors/embayments/river mouths of Lake Huron (Saginaw, Sturgeon Bays), Lake Michigan, and Lake Ontario. Over the past 15 years (2001-2016), we have conducted annual late-summer and seasonal surveys for cyanobacteria, their pigments, toxins and volatile organic compounds (VOCs) across inshore/offshore sites in Lake Ontario and its eutrophic embayments (Sodus Bay, Bay of Quinte, Hamilton Harbour). Offshore waters generally showed low levels of these parameters but near shore regions and embayments had detectable, sometimes elevated cyanobacteria biomass/pigments, toxins and VOCs. Levels of the cyanotoxin microcystin in offshore waters fell below the Health Canada and US-EPA guidelines for safe drinking water (ca 1.6 ug/L); However samples from embayments periodically exceeded these guidelines. Several samples from the Bay of Quinte and Sodus Bay exceeded the WHO recommended guidelines for recreational contact (20 ug/L). These events demonstrate that the cHAB issue is not restricted to Lake Erie, and emphasize the need for more rigorous, system-wide monitoring and management. *Keywords: Cyanophyta, Toxins, Lake Ontario, Microcystin, Harmful algal blooms, Embayments.*

BRADFORD, A.[1], MALLOY, S.[2], and DURHAM, L.[2], [1]University of Guelph, School of Engineering, Guelph, ON, N1C 1B1, CANADA; [2]Credit Valley Conservation, 1255 Old Derry Road, Mississauga, ON, L5N 6R4, CANADA. **Hydrologic and Water Quality Benefits of Green Infrastructure Retrofit of Commercial Property.**

The IMAX Corporation retrofitted the employee parking lot at their headquarters in Mississauga, Ontario with green infrastructure. The retrofit, and contributions of industry partners, provided the opportunity for long-term research. Seven separate systems within the parking lot were instrumented: three permeable pavement areas, three bioretention systems, and one asphalt control. Data has been collected since 2013 and the systems are being assessed with respect to hydrologic, water quality and other criteria. After construction there were some leakage issues and the drainage areas were found to deviate from the design. The identified issues have been corrected or taken into account in the analysis and interpretation. The data set for 2014 and 2015 included more than 70 events larger than 2 mm, including 6 events larger than 35 mm and 2 events larger than 60 mm, providing a good basis for assessment of hydrologic performance. At least 15 water quality samples were collected from most of the systems during this period, allowing for a preliminary assessment of water quality performance for the non-winter season. The research findings will be used to inform guidance on design and operation and to predict the effectiveness of green infrastructure

practices implemented on a (sub)watershed scale. *Keywords: Permeable pavement, Mitigation, Low impact development, Urbanization, Bioretention.*

BRAMBURGER, A.J.[1], REAVIE, E.D.[1], SGRO, G.V.[2], ESTEPP, L.R.[1], SHAW CHRAIBI, V.L.[3], and PILLSBURY, R.W.[4], [1]Natural Resources Research Institute, University of Minnesota Duluth, Duluth, MN, 55812, USA; [2]John Carroll University, University Heights, OH, USA; [3]University of Nebraska-Linkon, Lincoln, NE, USA; [4]University of Wisconsin Oshkosh, Oshkosh, WI, USA. **Do they know about shrinkage? Decreasing diatom cell size in the Great Lakes (1900-2015).**

Size distributions in diatom assemblages may be influenced by a number of mechanisms including community-level taxonomic reorganization and population-level demographic shifts. We examined historical trends in diatom cell size in the Laurentian Great Lakes. Our results demonstrated a gradual (5.11 µm3/yr.) decline in mean diatom cell size across the basin. Mean diatom cell size decreased significantly in Lakes Superior, Erie and Ontario while no significant trends were observed for Michigan and Huron. In Superior and Ontario species-specific mean cell size decreased over the course of the 20th century, suggesting demographic shifts towards populations dominated by smaller, later-generation individuals. Contrastingly, species-specific mean cell size increased in Michigan and Erie. Community re-organization, manifested as size-specific rates of relative abundance change (larger taxa tended to decrease while smaller taxa tended to increase), was observed in all lakes except Michigan. These shifts towards communities dominated by smaller taxa exacerbated (Superior, Huron, Ontario) or mitigated (Michigan, Erie) the effects of demographic shifts. Basin-wide decrease in diatom cell size duting the 20th century demonstrates the ability of climate change to drive changes in the primary producer community of large freshwater systems. *Keywords: Paleolimnology, Size change, Diatoms, Climate change.*

BRANDEL, A.M. and HUNTLEY, J.F., University of Toledo-HSC, 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 lake-dwelling cyanobacteria, including *Microcystis* sp. and *Planktothrix* sp. Harmful algal blooms in Lake Erie have become a major human health concern in recent years, highlighted by the August 2014 do not drink order issued by the City of Toledo to roughly half a million residents over three days. Given that MC-LR is a molecule containing 7 amino acids, we hypothesized that naturally-occurring Lake Erie bacteria use MC-LR as a "free" energy source. Further, isolation and characterization of such MC-LR-degrading bacteria could lead to the development of safe

and cost-effective methods to remove MC-LR from drinking water. To test this hypothesis, we collected water samples throughout the summer of 2015 from various locations in Lake Erie, spiked each sample with 100 ppb of MC-LR once per week to enrich for MC-LR-degrading bacteria, and tested MC-LR degradation over the course of three weeks. Our data demonstrate that MC-LR-degrading bacteria are present in Lake Erie and that these bacteria rapidly remove high levels of MC-LR from water. Further, sequence analysis revealed that a diverse array of bacteria degrade MC-LR. Current studies are developing and testing the ability of individual bacterial clones to be used as water-purifying biofilters. *Keywords: Algae, Microcystin toxin, Harmful algal blooms, Degradation, Lake Erie, Biofilm.*

BRATTON, J.F.[1], VERHAMME, E.M.[1], and BRIDGEMAN, T.B.[2], [1]LimnoTech, 501 Avis Drive, Ann Arbor, Mi, 48108, USA; [2]University of Toledo, Lake Erie Center, 6200 Bayshore Road, Oregon, OH, 34618, USA. **Just-in-Time Data Delivery: Adaptation of HABs Researchers to Changing Data Sharing Expectations.**

In traditional HABs research projects, data and sample collection happens in the summer, processing and analysis take place over the fall and winter, and results are presented the following year, and eventually published. This paradigm is shifting in Lake Erie as stakeholders, funding agencies, and the media are coming to expect instant access to continuous observations from *in situ* sensors, and access within hours to processed satellite images, lab analytical results, and model outputs. This pseudo-operationalization of research data collection and analysis presents some unique logistical, organizational, and even ethical challenges. With little time for interpretation, preliminary research data and real-time observations have the potential to be misinterpreted by end users. In the absence of operational monitoring networks, researchers also feel pressure to divert their energies away from execution of process studies and experiments, and development of new techniques, to collect and communicate more routine monitoring data. This presentation will highlight a variety of the data delivery methods being used by Lake Erie HABs researchers, and discuss efficient ways to provide timely updates to stakeholders of changing conditions. Examples of effective HABs data sharing from other regions will also be presented. *Keywords: Harmful algal blooms, Data sharing, Monitoring, Research, Decision making, Communication.*

BREEDERLAND, M.A.[1], SAMPLES, A.[2], and CARPENTER, D.D.[3], [1]Michigan Sea Grant Extension, 520 W Front St. STE A, Traverse City, MI, 49684, USA; [2]Michigan Sea Grant, 520 E. Liberty St. STE 310, Ann Arbor, MI, 48104, USA; [3]Lawrence Technological University, 21000 W. 10 Mile Rd., Southfield, MI, 48075, USA. **Small Harbor Sustainability in Michigan: Strategies and Lessons Learned from 4 Coastal Communities.**

Michigan is home to more than 80 public harbors and marinas on the Great Lakes coastline. These harbor communities often serve as place-based economic centers but can be impacted by multiple coastal factors including varying water levels and impact storms all placed in the distinct community context of its history and vision-planning for the future. In 2014-2015, a multidisciplinary project team and an advisory board worked to develop an overall strategy for financial, social, and environmental management and sustainability for Michigan's small harbors. Essential elements included gathering and compiling social, economic, environmental, infrastructure, and recreational information for four Michigan coastal communities. A broad-based community visioning process occurred in a series of three public meetings per community, including an intensive three-day public charrette, where local stakeholders shared their visions and ideas for their waterfront in a structured set of planning exercises. Common threads and lessons learned on economic and coastal community resiliency will be shared based upon the rigorous community participation approach, field observations, input from the advisory board, waterfront stakeholders, and the research team. *Keywords: Planning, Working Waterfronts, Urban areas, Sustainability, Vision.*

BRILAND, R.D., HU, C., WITUSZYNSKI, D., LEE, J.Y., MARTIN, J., and LUDSIN, S.A., The Ohio State University, Columbus, OH, 43212, USA. **Cyanobloom 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 toxins that can negatively affect organisms and bioaccumulate in the aquatic food web. To begin to assess how cyanobacteria can influence 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 2014 (n = 5 sampling events). We used satellite imagery to guide our sampling, thus allowing our sites to encompass a range of cyanobacteria concentrations (0 mg/L to 22 mg/L). Sites with cyanoblooms were characterized by high algal biomass dominated by *Microcystis* spp., high microcystin concentration, and low water transparency. We also found strong positive relationships between cyanobacteria intensity and consumer (both zooplankton and fish) abundance, indicating that higher consumers are not avoiding cyanoblooms (at least during the day). In addition, we expound on these findings and discuss their implications for fisheries ecology and management. *Keywords: Food chains, Eutrophication, Harmful algal blooms.*

BRILEY, L.J.[1], ROOD, R.B.[1], STEINER, A.[2], GIBBONS, E.H.[1], and BAULE, W.J.[1], [1]Great Lakes Integrated Sciences + Assessments, 625 E. Liberty St, Suite 300, Ann Arbor, MI, 48104, USA; [2]University of Michigan, 2455 Hayward St., Ann Arbor, MI, 48109, USA. **Ensemble of Climate Models for Great Lakes Decision Making.**

The U.S. Great Lakes are known for their impact on local and regional weather and climate. However, the processes responsible for producing lake-effects and lake-induced modifications of weather are often poorly represented or missing from climate models. As a result, many of the widely used sets of climate model projections (i.e., CMIP) and derivatives of them (i.e., statistically downscaled projections) are not only missing valuable information that decision makers require when planning for the future, but in some instances they represent a completely different climate system unlike the Great Lakes region. In order to address this gap between end user needs and available model-based data and information, the Great Lakes Integrated Sciences + Assessments (GLISA) program is bringing together a team of regional climate modeling experts and extension specialists to develop a Great Lakes Ensemble. The goal of the Ensemble project is to develop an evaluation framework, which will be applied to several climate model data sets--including regional modeling efforts--to provide a regional perspective on the quality of information coming from the models. This talk describes the plans, and invites community participation in design and evaluation of the ensemble. *Keywords: Atmosphere-lake interaction, Climate Projections, Climate change, Decision Making.*

BRINSMEAD, J.K. and MACDONALD, F., Ontario Ministry of Natural Resources and Forestry, 300 Water St., Peterborough, ON, K9M 8M5, CANADA. **Getting Ahead of the Learning Curve: Ontario Lessons Learned in Response to Aquatic Invasive Species.**

Once established, aquatic invasive species (AIS) are very difficult and expensive to eradicate or control, making prevention the most cost effective means of avoiding related impacts and expenses. However, when prevention measures fail, responding to AIS when populations are small and localized often presents the only opportunity to eliminate a species, avoiding the associated long-term impacts and management costs. Ontario has a long history of non-native aquatic species introductions. Many of these species have thrived in the temperate climate of the Great Lakes basin and have become highly invasive. In recent years, Ontario has greatly increased the priority of and efforts related to AIS prevention and response. An overview of recent response projects will be provided as well as lessons learned during field responses. In 2015, a workshop was held involving field and policy staff of the Ontario Ministry of Natural Resources and Forestry who had previously participated in AIS response projects. Key challenges and recommendations from the workshop regarding needed tools and resources to facilitate effective responses in the province will be discussed. Documenting and discussing the results of response projects, including recommendations to apply to future projects, will help improve response capacity in Ontario and elsewhere. *Keywords: Invasive species, Prevention and response, Management.*

BRINSMEAD, J.K. and DOWNE, J.R., Ontario Ministry of Natural Resources and Forestry, 300 Water St., Peterborough, ON, K9J 8M5, CANADA. **A Risk Assessment Framework to Support the Ontario Invasive Species Act.**

While Ontario has a long history of non-native aquatic species introductions, there are many more non-native species that could enter the province through a variety of pathways. The Invasive Species Act, which received Royal Ascent by the Ontario Government in November 2015, provides a number of tools, including regulatory tools, to prevent further introductions and spread of species that could become invasive and have adverse ecological and socio-economic impacts. However, before actions can be taken, a framework for determining the risk posed by species and pathways needs to be developed. While science-based ecological risk assessment will form the backbone of this framework, a number of other factors need to be considered by the Ontario Government. These factors include identifying species and pathways that need to be assessed, evaluating the socio-economic impacts species are likely to have if they become established, and contrasting ecological and socio-economic impacts caused by the species to the socio-economic impacts that regulating a species or pathway may have on Ontarians. A multi-phase holistic framework for prioritizing invasive species for regulatory and other management actions based in the principles of risk analysis will be discussed for Ontario. *Keywords: Invasive species, Ecological risk, Risk assessment, Socio-economic risk.*

BROADWAY, K.[1], PANGLE, K.L.[1], GALAROWICZ, T.L.[1], CLARAMUNT, R.M.[2], and JONAS, J.L.[2], [1]Central Michigan University, Mount Pleasant, MI, USA; [2]Michigan Department of Natural Resources, Charlevoix, MI, USA. **Habitat use and spawning behavior of a unique Lake Trout population in Elk Lake, MI.**

Lake Michigan Lake Trout populations collapsed during the middle twentieth century, restoration efforts since have primarily relied upon stocking extant or non-indigenous forms. These efforts have had limited success pointing to the need to consider other forms. A self-sustaining Lake Trout population resides in Elk Lake, which have proven to be both genetically and morphologically distinct from other Great Lakes forms. We aimed to determine if this population also distinguishes themselves behaviorally and reproductively. We used acoustic telemetry, survey catch-per-unit-effort, egg-predator diets, and passive egg collection to characterize the spawning and distribution patterns. Hydro-acoustics was used to define bottom substrates throughout the basin. Preliminary results suggest these fish reside in water greater than 100 feet in depth during most of the year, remain in deep-water during the spawning period, and do not appear to be reef spawners. These fish appear to spawn in deep water over clay substrate, a unique spawning behavior in relation to current recognized forms in Lake Michigan. If rehabilitation efforts in Lake Michigan continue to rely upon stocking, known self-sustaining strains as found in Elk Lake may warrant strong consideration for inclusion in future restoration efforts. *Keywords: Lake trout, Habitats, Fish behavior.*

BRONTE, C.R.[1], HASKA, C.[2], DETTMERS, J.M.[2], KRUEGER, C.C.[3], BLEVINS, Z.W.[2], MUIR, A.M.[2], and KORNIS, M.S.[1], [1]U.S. Fish and Wildlife Service, 2661 Scott Tower Drive, New Franken, WI, 54229, USA; [2]Great Lakes Fishery Commission, 2100 Commonwealth Blvd., Suite 100, Ann Arbor, MI, 48105, USA; [3]Michigan State University, 1405 South Harrison Road, 115 Manly Miles Building, East Lansing, MI, 48823-5243, USA. **A retrospective analysis of coregonine stocking efforts for restoration.**

Historically, coregonines were the principal prey in the Great Lakes and supported large fisheries, and provided forage for the largest lake trout populations in the world. The collapse of cisco and the deepwater ciscoes during the 1920-1960s altered energy flow and predator-prey dynamics throughout the basin. With reductions of non-native prey across all the Great Lakes, restoration of native coregonines through stocking is now being considered. Several Great Lakes hatchery managers travelled to Finland in 2012 and 2014 to observe and transfer knowledge from well-established coregonine brood stock and culture programs in large-scale government and private facilities. To augment the knowledge gained from that trip, this study examined the efficacy of coregonine stocking programs in North America, Europe, and Asia. A retrospective analysis from the published literature was conducted to evaluate variables associated with stocking programs that contributed to success in reestablishment. Variables analyzed were size/age at stocking, numbers and densities released, and gamete source, and the conditions of the receiving waters. Based on the study's findings, proposed culture and stocking protocols will be refined and adapted to provide the best opportunity to restore extirpated coregonines in the Great Lakes. *Keywords: Restoration, Coregonine.*

BRONTE, C.R.[1], HOLEY, M.E.[1], and DETTMERS, J.M.[2], [1]U.S. Fish and Wildlife Service, 2661 Scott Tower Drive, New Franken, WI, 54229, USA; [2]Great Lakes Fishery Commission, 2100 Commonwealth Blvd, Suite 100, Ann Arbor, MI, 48105, USA. **Opportunities and challenges for coregonine restoration the Great Lakes-a general overview.**

Historically the Great Lakes contained six closely related deepwater ciscoes (Coregonus hoyi, johannae, kiyi, nigripinnis, reighardi, zenithicus) and the cisco (artedi). These fish fed on benthos and plankton, were forage for lake trout and other predators, and supported large commercial fisheries. During 1940-60, overfishing and exotic species caused the loss of many of these species. Cisco survives in moderate abundances in lakes Superior and Huron, but in small remnant populations elsewhere. C. hoyi, kiyi, and zenithicus, can be found in Lake Superior, the only lake with its original complex. C. hoyi also survives in lakes Michigan and Huron, C. johannae, and C. reighardi went extinct, and C. nigripinnis were extirpated. Stocking of non-native salmonines has reduced alewives to low levels and allowed some native species to recover. Efforts and proposals are in place to reintroduce these species from remnant populations. Opportunities include ecosystem changes that favor native fishes and increased appreciation for native diversity. Challenges include the scale of the Great Lakes, limited source stocks for reintroduction, limited knowledge of deep-water coregonines culture,reduced productivity to support reintroduced coregonines, and narrow conceptual models of what was lost influenced by remnant populations. *Keywords: Coregonine, Restoration.*

BROOKS, C.N.[1], GRIMM, A.G.[1], HUCKINS, C.[2], MARCARELLI, A.[2], VAN GOETHEM, R.[2], and DOBSON, R.J.[1], [1]Michigan Tech Research Institute, Michigan Technological University, 3600 Green Ct., Ste. 100, Ann Arbor, Mi, 48105, USA; [2]Biological Sciences, Michigan Technological University, 1400 Townsend Dr., Houghton, MI, 49931, USA. **Evaluating the spread and control of Eurasian watermilfoil through remote sensing technologies.**

Eurasian watermilfoil, Myriophyllum spicatum, (EWM) is a non-native aquatic plant first documented in the U.S. in the 1940s and now present in all of the Great Lakes. It can crowd out native plants, hybridizes with native milfoil, and can be a nuisance to recreation. Extensive control efforts often provide only short-term relief. Projects funded through the U.S. EPA Great Lakes Restoration Initiative (GLRI) and the Michigan DNR have enabled a Michigan Tech team to demonstrate methods to help arrest the spread of EWM and evaluate the effectiveness of multifaceted control measures. These projects include applying remote sensing technologies to help understand the locations and spread of EWM, and to assess the effectiveness of control efforts. Imagery collected using satellite and unmanned aerial vehicle (UAV) platforms have been used to create classifications of cover types to map the locations of EWM in northern Great Lakes study areas. Spectral profiles of EWM and other macrophytes have been collected to create unique signatures to aid in mapping, with EWM appearing distinct in the 500-650 nm (green to red) wavelengths. Approaches to practical application include collecting data over larger areas with a UAV, completing development of a EWM spectral algorithm, and monitoring a site undergoing treatment for EWM. *Keywords: Littoral zone, Invasive species, Remote sensing.*

BROTHERS, S.M.[1], VOGT, R.[2], XENOPOULOS, M.A.[2], and SIBLEY, P.[1], [1]University of Guelph, Gordon St., Guelph, ON, N1G 2W1, CANADA; [2]Trent University, 1600 W. Bank Dr., Peterborough, ON, K9J 7B8, CANADA. **Could Lake Erie Be Experiencing a Brownification-Anoxia Feedback Loop?**

Lake Erie's Central Basin is experiencing an increasing number of hypoxic and anoxic events, and recent studies suggest that it is also one of the only areas of the Great Lakes which has become more turbid in recent decades, despite the introduction of water-filtering Dreissenid mussels and a net decline in Chlorophyll *a* concentration. In shallow lakes, declines in water clarity have been linked to biogeochemical feedback loops involving the internal loading of dissolved organic carbon (DOC), iron, and nutrients from the sediments into the water column, and resulting in extended periods of hypoxia or anoxia. Declines in water clarity and benthic algal production are believed to be key elements fueling this process. Could Lake Erie be experiencing a benthic feedback-loop analogous to that described for shallow lakes? We argue that declines in benthic algal production in coastal zones and consequent oxidation-reduction (redox) reactions at the sediment-water interface may help explain the recent increase in the frequency and intensity of hypoxic and anoxic events in Lake Erie's Central Basin. We additionally present recent measurements of DOC concentrations in Lake Erie, and examine how these may help us understand changes in the ecological state of the lake. *Keywords: Biogeochemistry, Benthos, Carbon.*

BRUESTLE, E.[1], GORSKY, D.[2], KARBOSKI, C.T.[2], and BIESINGER, Z.[2], [1]Great Lakes Center, SUNY Buffalo State, 1300 Elmwood Ave, Buffalo, NY, 14222, USA; [2]USFWS, 1101 Casey Rd, Basom, NY, 14013, USA. **Lake Sturgeon Diet Composition and Trophic Position in the Lower Niagara River.**

Lake Sturgeon, *Acipenser fulvescens*, a native top predator, were once abundantly distributed throughout the Laurentian Great Lakes. However, widespread overharvest and habitat degradation has greatly diminished their numbers. The lower Niagara River contains one of the few remaining populations in New York State. Recent surveys indicate that this population is now recovering. The purpose of this study is to determine which food resources Lake Sturgeon are utilizing and their current trophic position in an invasive species dominated food web. The recent diet histories of Lake Sturgeon were identified through stomach content analysis. Stable δ15N and δ13C isotope analysis of blood and fin tissue was used to assess trophic position and carbon source at different time periods. We found that the most common diet items were, by a large percentage, invasive species. The amphipod *Echinogammarus ischnus* was the most prevalent by number whereas the Round Goby *Neogobius melanostomus* dominated by weight. In contrast to findings from other systems, lower Niagara River lake sturgeon generally do not feed upon invasive *Dreissena* spp. mussels possibly due to availability of higher quality food sources, such as gobies and amphipods. *Keywords: Food chains, Niagara River, Fish diets.*

BRUULSEMA, T.W., International Plant Nutrition Institute, 18 Maplewood Drive, Guelph, ON, N1G 1L8, CANADA. **Crop Nutrition Industry Action Opportunities for Sustainable Phosphorus Management.**

Responsible management of crop phosphorus nutrition needs to recognize synergies and trade-offs among several important areas of impact. The most important issues are global food security and water quality. In the Lake Erie watershed, continuing research reveals considerable complexities in the impacts of several practices with respect to reducing phosphorus loads. The 4Rs of nutrient stewardship--source, rate, time and place of nutrient application--interact with tillage, drainage, and cropping practices, and also with the indigenous properties of the soil and landscape. This presentation will review the knowledge base for quantifying impacts of these practices on crop productivity, soil health, nutrient use efficiency, and losses of dissolved and particulate forms of phosphate. It will also highlight ongoing research efforts, their preliminary results, and strategic opportunities for positive change, as well as efforts to enhance public communication of performance. *Keywords: Lake Erie, Eutrophication, Nutrients.*

BUDNIK, R.R.[1], MINER, J.G.[1], and MURRAY, C.[2], [1]Bowling Green State University, Bowling Green, OH, 43402, USA; [2]Pennsylvania Fish and Boat Commission, Fairview, PA, USA. **Use of DIDSON to Monitor Emigration of Stocked Juvenile Steelhead Trout.**

Over 2 million juvenile steelhead trout are stocked into Lake Erie tributaries each year to sustain a valuable sport fishery. Before contributing to the fishery, juvenile steelhead must emigrate to Lake Erie where they grow and mature. Although tremendous effort is put into stocking steelhead, little is known about the tributary residence time and survivorship of juvenile steelhead after stocking. Additionally, the influence that environmental conditions and size effects have on steelhead emigration has not been widely studied in this system. We implemented Dual Frequency Identification Sonar (DIDSON) near the mouth of a small Lake Erie tributary prior to stocking in order to measure juvenile steelhead emigration. Footage was recorded continuously over two stocking seasons (April-May 2014; April-June

2015) and total counts were determined every hour. Fish lengths were estimated using the DIDSON length measuring tool. DIDSON counts showed that the number of emigrants increased with increased water temperature and photoperiod but were not affected by discharge. Larger fish tended to emigrate earlier and most non-emigrating fish were found to be <140 mm. Population estimation with electroshocking was performed after the DIDSON sampling period and revealed that <6% of the steelhead trout stocked remained in Trout Run in both years. *Keywords: Fish management, Hydroacoustics, Trout.*

BUNNELL, D.B.[1], ARMENIO, P.M.[1], WARNER, D.M.[1], EATON, L.A.[1], EPPEHIMER, D.E.[1], NOWICKI, C.J.[2], and MAYER, C.M.[2], [1]USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105, USA; [2]University of Toledo, Toledo, USA. **Does proximity to high-loading tributaries enhance production in Lake Michigan?**

Over the past decade, Lake Michigan managers have been concerned about excessive nutrients impairing nearshore waters, especially given the ability of dreissenid mussels to "shunt" allochthanous phosphorus that enters the lake through tributaries to the nearshore. Understanding the distribution and abundance of nutrients and biota (e.g., invertebrates and fish) across a nearshore to offshore gradient remains a key knowledge gap, and can help inform the LAMP's Nearshore Strategy. In 2015, USGS seasonally sampled eight nearshore-to-offshore transects throughout Lake Michigan, with a design where the location of transects varied in their proximity to tributaries that deliver different levels of phosphorus. We provide preliminary results as to whether chlorophyll concentrations and fish biomass were higher in the nearshore, and whether nearshore values were highest when they were adjacent to tributaries with high phosphorus loading (e.g., St. Joseph, Manitowoc, Kalamazoo Rivers). We also compare our results to previous CSMI transects in Lakes Michigan from 2010 and Huron from 2012. *Keywords: Lake Michigan, Phytoplankton, Fisheries.*

BURCHER, R.S.[1], JOHNSTON, C.M.[2], GAOIT, J.[3], and JENKINSON, R.W.[4], [1]National Research Council Canada, 1200 Montreal Road, Ottawa, ON, K1A 0R6, CANADA; [2]U.S. Geological Survey, 331 Commerce Way, Pembroke, NH, USA; [3]Minister of Natural Resources and Forestry, 300 Water St, Peterborough, ON, K9J 8M5, CANADA; [4]International Joint Commission, 234 Laurier Avenue West, Ottawa, ON, K1P 6K6, CANADA. **Development of the SPARROW Stream Networks for the Great Lakes and Winnipeg River Basins.**

The Spatially Referenced Regression on Watershed attributes (SPARROW) model contributes insight to the transport and delivery of nutrients such as phosphorus and nitrogen from streams to downstream receiving waters. The International Joint Commission (IJC), in conjunction with the US Geologic Survey (USGS) and National Research Council

(NRC) is developing a SPARROW model that covers the mid-continental North America spanning west from the Red-Assiniboine, east to the Great Lakes basins and as far south as the confluence of the Mississippi and Ohio Rivers. An enhanced digital stream network is required for SPARROW to relate water-quality measurements to stream and watershed characteristics for predicting nutrient loads in unmonitiored streams. A consistent bi-national stream network suitable for SPARROW modeling did not exists for the study area at the start of the project. NRC and the USGS will provide an overview of the steps used to harmonize Canadian and US stream networks within the study basins. Background of the data, processes and tools used to construct the network from a bi-national network will focus on the unique processing requirements: network density, diversions, generalization of segments, DEM's, gauge stations, lakes, reach catchment generation and other attribute requirements. *Keywords: Great Lakes basin, SPARROW, GIS, Data, Spatial analysis.*

BURKE, H.E.[1], DYER, R.D.[2], and KELLY, R.I.[3], [1]Laurentian University, Sudbury, ON, CANADA; [2]Ontario Geological Survey, 933 Ramsey Lake Road, Sudbury, ON, P3E6B5, CANADA; [3]Ontario Ministry of Agriculture Food and Rural Affairs, 1 Stone Road West, Guelph, ON, N1G4Y2, CANADA. **Effects of Surficial Geology on Lake Erie Tributary Water and Sediment Phosphorous Concentrations.**

Since the 1970s, total phosphorous (P) loadings to the Great Lakes have been reduced drastically (IJC 2013). Paradoxically, Lake Erie has recently experienced large algal blooms thought to have resulted from a shift in the concentrations of tributary loadings of bioavailable P fractions (Ballantine at.al. 2009, Dolan & McGunagle 2005). The lack of accurate loading estimates from Ontario tributaries or understanding of P fractionation between water and sediment have led to an unexplained imbalance in Lake Erie's P budget (Han et.al. 2011, Richards et.al. 2013). The aim of this research is to study whether parent surficial geology plays a role in P fractionation between stream water and sediment of Lake Erie watersheds, and to guide future consideration of stream substrate properties when managing agricultural soils. Stream sediment and water samples were collected during spring, summer and fall of 2013 from 8 different watersheds in Ontario including the Thames and Grand Rivers. Results show wide variation in total P concentration in sediment (142 to >1700 mg/L) and water (<30 to 7858 mg/L) between and within selected watersheds across similar geological conditions and dominant land-uses. Significant findings to date include the role of sediment grain size and sources in the binding retention of nutrients in river substrates. *Keywords: Surficial geology, Nutrients, Lake Erie, Phosphorus, Sediments.*

BURLAKOVA, L.E.[1], BARBIERO, R.P.[2], KARATAYEV, A.Y.[1], and DANIEL, S.E.[1], [1]Great Lakes Center, SUNY Buffalo State, 1300 Elmwood Ave., Buffalo, NY, 14222, USA; [2]CSRA, 1359 W. Elmdale Ave, Suite #2, Chicago, IL, 60660, USA. **What's on the bottom? Spatial gradients and temporal changes in Great Lakes benthic communities.**

In 1997 the Great Lakes National Program Office of the US EPA began a monitoring program of benthic communities across all five Laurentian Great Lakes to complement its existing offshore surveillance sampling. This program, the most spatially extensive on the Great Lakes, routinely surveys over 50 stations across the lakes every summer, with an emphasis on deeper (> 50 m) sites. In addition to the extent of coverage, a unique aspect of this monitoring program is the fact that a single agency oversees the work, thus ensuring consistency in sampling and analytical methods. We used non-parametric multivariate analyses to provide a general description of the offshore benthic communities of all five Great Lakes using data collected from this program between 1997 and 2013. Our goal was to characterize large-scale patterns of distribution of benthic communities, both spatially and temporally, over the course of the program. We found that the major drivers of the distribution, abundance, and species richness of benthic invertebrates were depth, chlorophyll a, and nutrients. Our analysis distinguished the major groups of benthic invertebrates along lake depths and trophic gradients. In addition, we will describe changes in benthic community structure and species dominance during the 15 years of monitoring.

Keywords: Benthos, Community structure, Monitoring, Biodiversity.

BURNS, W.D., NCSCE at Stony Brook University, 2000 P St NW, Suite 210, Washington, DC, 20036, USA. **SENCER: A Community of Transformation.**

SENCER (Science Education for New Civic Engagements and Responsibilities) is the signature program of the National Center for Science and Civic Engagement at Stony Brook University. Launched in 2001 as a NSF national dissemination project and now recognized as a community of transformation, SENCER improves learning by "applying the science to learning to the learning of science." This means not just adopting and supporting improved pedagogical practices (such as active learning, undergraduate research, peer mentoring, and service learning), though these are valuable strategies to improve learning that we advocate. The SENCER approach incorporates these progressive practices in the context of what some researchers have called its core "philosophy" (Kezar & Gherke, 2015): SENCER uses the urgency and significance of the complex and pressing civic challenges that have been called "multidisciplinary trouble" (Osborn 1986, Burns 2014). With the SENCER philosophy the goal for students is to make learning real, relevant, rigorous and responsible. The goal for our collaborating institutions is to help them achieve their particular missions for liberally educated students. The goal for our democracy is to cultivate and increase our students' capacities to engage, as responsible citizens, with the great issues of our time. *Keywords: Environmental education, Partnerships, Watersheds, Student Leadership, Environmental health.*

BUTTS, E.K. and CARRICK, H.J., Central Michigan University, Dept. of Biology and Institute for Great Lakes Research, Mount Pleasant, MI, 48859, USA. **Dynamics of key phytoplankton populations in Lake Michigan: Biomass, growth, and grazing losses.**

The phytoplankton assemblage in Lake Michigan has undergone considerable changes, such that the occurrence of seasonal diatom blooms and subsurface phytoplankton maxima are no longer present. That said, these observations have been derived from a limited geographic region in the lake (southern portion of the lake). Our sampling was conducted from 2013 - 2015 throughout the stratification period (i.e. spring to fall) for a total of 9 cruises on transects out of Muskegon, Waukegan. Racine, Saugatuck, St. Joseph and a long-term EPA site in the middle of the basin (M118). We used in vitro experiments coupled with microscopic counts we were able to calculate biomass, growth and grazing. The experiments performed included antibiotic experiments and dilution experiments. Our findings show that the majority of chlorophyll was contributed by small phototrophic picoplankton (Ppico) < 2 μm. Their growth and grazing was balanced but often growth offshore was greater than nearshore. The dominant nanoplankton were the phototrophic flagellates Rhodomonas minuta and Chrysochromulina Parva,whose growth and grazing losses were also in balance. These results suggest that tight coupling occurred between both pico and nanoplankton and their predators in Lake Michigan. *Keywords: Algae, Lake Michigan, Food chains.*

BYUN, K. and HAMLET, A.F., University of Notre Dame, Notre Dame, IN, 46556, USA. **Hydrological Responses to Climate Change in the Midwest Great Lakes Watersheds.**

Climate change projections of changing hydrologic behavior in the Midwest and Great Lakes region are needed for the assessment of climate change impacts on natural environments and human systems. For hydrological impact analysis, we downscaled an ensemble of 10 GCM scenarios from the Coupled Model Inter-comparison, Phase5 (CMIP5) to produce meteorological forcing data sets for the Variable Infiltration Capacity (VIC) hydrologic model, implemented over the Midwest and Great Lakes Drainages at 1/16 degree resolution. The projected regional climate for the RCP 8.5 emissions scenario shows substantial change for the region by the 2050s as compared to a historical baseline (1971-

2000). Monthly temperature is projected to increase approximately 3°C to 7°C by the 2050s, and monthly precipitation is projected to increase in winter and decrease in summer, with precipitation changes ranging from -20 to 30% relative to historical baselines. Annual precipitation typically increases. To illustrate mid-21st-century climate change impacts expected in the lower Great Lakes drainages, we present changes in snowpack, monthly streamflow, soil moisture, ET, and hydrologic extremes (Q100 and 7Q10) for two large rivers draining to Lake Michigan: the St. Joseph River in MI and IN, and the Wolf River in Northern WI. *Keywords: Climate change, Hydrologic cycle, Watersheds.*

BZONEK, P.[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. **Common Carp movement in response to acoustic and strobe-light barriers in a mesocosm.**

The most likely pathway of Asian carp invasions into the Great Lakes is dispersal across geographic bottlenecks, such as canals or rivers. Non-permanent, behavioural barriers have been proposed as an inexpensive means to prevent carp expansion past these bottlenecks while maintaining water flow and human use. Our research examines Common Carp (*Cyprinus carpio*) behaviour in response to acoustic and strobe-light stimuli. An outdoor mesocosm with an environment similar to a canal was used to observe Common Carp movement, activity, and passes across a barrier. Common Carp (n=13) were implanted with acoustic telemetry tags and their behaviour was compared between trials with exposure to control, acoustic, and strobe-light barriers for 60-minute periods. Trials were run during both day and night. 12 strobe lights were deployed across the centre of the mesocosm at water depths of 3 m and 6 m. The acoustic stimulus is a combination of a marine engine, a 200-1400Hz sweep, and a 200-1500Hz bandsweep. The acoustic stimulus was played through an underwater speaker at a depth of 4 m and a sound pressure of 160db. These findings may help inform policy and management decisions regarding the potential use of behavioural barriers against Asian carps and other aquatic invasive species. *Keywords: Invasive species, Asian Carp, Management, Behavioural barrier, Fish behavior, Mesocosm.*

C

CADENA, S.[1], MARKOVIC, S.[1], DOAN, P.[1], WATSON, S.B.[2], GUO, J.[2], MCCLURE, C.[3], MUGALINGAM, S.[3], MORLEY, A.[4], and DITTRICH, M.[1], [1]University of Toronto Scarborough, 1265 Military Trail, Scarborough, ON, M1C 1A4, CANADA; [2]Environment Canada, National Water Research Institute, 867 Lakeshore Rd., Burlington, ON, L7R4A6, CANADA; [3]Lower Trent Conservation, 714 Murray Street, Trenton, ON, K8V5P4, CANADA; [4]Minister of the Environment and Climate Change, Eastern Regions, 1259 Gardiners Road, Unit 3, P.O. Box 22032, Kingston, ON, K7M 8S5, CANADA. **Phosphorus Dynamics and Mechanism of Release in Sediments of the Bay of Quinte, Canada.**

Phosphorus (P) is an important driver of eutrophication and loss of water quality in freshwater ecosystems. Lacustrine sediments are a rich source of P and a major factor in nutrients cycling. Despite considerable efforts to reduce external P loading, eutrophication and seasonal harmful algal blooms are a persistent problem in the Bay of Quinte. Hence, an understanding of the P speciation, P dynamics and mechanism of release is fundamental for management strategies aiming prevention of eutrophication. The purpose of this study is to quantify the P binding forms in sediments, their contribution to internal loading under seasonal changes in oxygen, redox and pH conditions as well as gain insight of the mechanism of P release in the Bay of Quinte. Analysis of the sediments collected from three basins included metals and P determination in pore water, P sequential chemical extraction and oxygen, redox and pH profiling during a period of two years. Results of these analyses showed organic-P and redox sensitive P as the predominant P binding forms present in sediments. The phosphorus flux from sediments showed distinct seasonality with the highest values during mid-summer and the P retention capacity of the sediments is limited based on threshold sediment concentrations of Al, Fe and P fractions. *Keywords: Phosphorus, Mechanism of Release, Eutrophication, Bay of Quinte.*

<u>CALAPPI, T.J.</u> and MCCLERREN, M.A., US Army Corps of Engineers, 477 Michigan Ave, Detroit, MI, 48226, USA. **Establishment of Compensating Works Gate Movement Limits to Prevent Fish Stranding.**

The International Lake Superior Board of Control is responsible for monthly regulation of Lake Superior. Most discharge adjustments are made through hydropower adjustment; however, flow is released through a flow compensation structure at the St Marys Rapids as well. The last decade has seen increased coordination with multinational stakeholders when gate changes are required. Rapid changes in hydraulic parameters can have a large affect on various species living in or near the banks of the river. In the summer of 2015, the U.S. Army Corps of Engineers measured depth and velocities in the rapids to understand dynamics of gate changes. The U.S. Army Corps of Engineers developed a plan using various technologies to measure conditions in the rapids for various gate changes. Water levels were continuously monitored and a series of discharge measurements were completed to measure the difference in hydraulic parameters for different gate openings. The data collected will help inform decisions on gate opening rates based on

recommendations from fishery biologists. Ultimately these data will be used in conjunction with hydrodynamic modeling to inform the full range of conditions expected in the St. Marys Rapids. The results of the study will create a set of recommendations for gate changes to minimize their affect on aquatic life. *Keywords: Ecosystem modeling, Hydrodynamic model, St. Marys River.*

CAMPBELL, S.D. and CHOW-FRASER, P., McMaster University, Main Street West, Hamilton, ON, L8S 4K1, CANADA. **Factors Influencing Water Quality in Sheltered Embayments of Eastern Georgian Bay, Lake Huron.**

Water quality in the nearshore zone of eastern Georgian Bay is described as being in excellent condition. Despite this, there have been recurring episodes of nuisance algal blooms, hypolimnetic oxygen depletion and internal phosphorus loading in several embayments. Anthropogenic disturbances and limited exchange of water with greater Georgian Bay are hypothesized to be key stressors leading to these problems. In order to understand these occurrences, we are using a comparative approach to evaluate the relative importance of independent variables (e.g. primary nutrients, physicochemical parameters and chlorophyll) for 10 embayments that vary along a gradient of cottage and marina development, morphometric parameters and catchment size. We found significant positive relationships between measures of development (e.g. cottage and road density) and total phosphorus. The demand for cottages and other recreational facilities in Georgian Bay will likely continue to increase. A better understanding of how morphometric, anthropogenic and landscape factors influence nutrient loading needs to be achieved in order to better manage these unique coastal ecosystems. *Keywords: Water quality.*

CAMPBELL, S.E. and MANDRAK, N.E., University of Toronto, 1265 Military Trail, Scarborough, ON, M1C 1A4, CANADA. **Functional Traits of Failed Fish Introductions in the Great Lakes.**

As the number of non-native species introductions continues to increase, the need for tools to predict potential invaders has become a central focus in invasion ecology. Recently, trait-based models have become a popular method used to predict invaders. These models predict the establishment, spread, and/or impact of potential invaders based on ecological and life-history traits. However, most of these models fail to address the role of propagule pressure in failed invasions. Due to a lack of data, many studies cannot incorporate failed invasions into their models. We analyzed the relationship between the functional diversity of non-native species, both successful and failed, and native species in the Great Lakes from 1870 to 2010. We only examined failed invasions where there was an environmental match and we had a record of deliberate stocking and, thus, sufficient propagule pressure to establish. This allows us to directly test the role of biotic interactions and this analysis will elucidate the role of functional traits in the success of an invader. *Keywords: Great Lakes Basin, Functional diversity, Failed invasions.*

CAPELLI, C.[1], BALLOT, A.[2], CERASINO, L.[1], and SALMASO, N.[1], [1]IASMA Research and Innovation Centre, Istituto Agrario di S. Michele all'Adige - Fondazione E. Mach, Via E. Mach 1, S. Michele all'Adige, TN, 38010, ITALY; [2]Norwegian Institute for Water Research (NIVA), Gaustadalléen 21, Oslo, NO, 0349, NORWAY. **Distribution of *Dolichospermum* in European waterbodies: a multidisciplinary approach.**

Dolichospermum lemmermannii is distributed in northern temperate and boreal regions. In the last 20 years, this Nostocales species appeared in all the large (62-368 km^2) lakes south of the Alps (Garda, Iseo, Como and Maggiore), often in the form of summer water blooms. The study of the sub-fossil akinetes in sediment cores allowed to antedate the introduction of *Dolichospermum* in Lake Garda between the 1960s and the 1970s. The successive establishment was hypothesized to be linked to the increase of nutrients following the economic development of the region, and to the high warming documented in this lake district. The new recent spread of this species in Southern Europe emphasizes the ecological heterogeneity and the possible existence of ecotypes, confirmed by the recent discovery of strains showing high temperature optima for growth. In this work, the biogeography and characteristics of strains isolated in different European climatic regions were carried out by adopting a multidisciplinary approach. A phylogenetic study of the 16S rRNA and *rpoB* genes was integrated with the assessment of the toxic potential by PCR and LC-MS. The study will contribute to identify better management options aimed to mitigate the effects of this new cyanobacterium on the large subalpine lakes. *Keywords: Cyanophyta, Cyanotoxins, Harmful algal blooms.*

CARRICK, H.J.[1], CAFFERTY, E.[1], STIMETZ, A.[1], POTHOVEN, S.A.[2], and FAHNENSTIEL, G.L.[3], [1]Central Michigan University, Dept. of Biology and Institute for Great Lakes Research, Mount Pleasant, MI, 48859, USA; [2]National Oceanic and Atmospheric Administration, Lake Michigan Field Station, Muskegon, MI, USA; [3]Michigan Technological University, Great lakes Research Center, Houghton, MI, 49931, USA. **Dynamics of Picoplankton in Lake Superior: Close Coupling Between Growth and Grazing Losses.**

Pico-sized plankton play an important role in regulating the key biogeochemical cycles in most pelagic environments. Here, we presented some of few seasonal estimates for both heterotrophic (Hpico) and phototrophic (Ppico) picoplankton abundance (direct

counts, n=27 and 36, respectively) and population dynamics (antibiotic experiments, n=30) in Lake Superior. Two offshore stations in the central basin of Lake Superior were sampled from a small research vessel (R/V Agassiz,) on six cruises at monthly intervals in 2013 (May-October). Both Hpico and Ppico were abundant contributors in all samples, typical for lakes with chlorophyll levels < 1 µg • L-1. Hpico abundance ranged from 140 to 871 x 103 cells • mL-1, and on average, supported ~10-fold greater numbers compared with the abundance of Ppico. Fractionated chlorophyll analysis revealed that algae in the 2-20 µm size category (nanoplankton) constituted > 50% of the assemblage while the Ppico size fraction constituted ~25%. Hpico grazing rates (-0.88 +/- 0.43) were consistently greater than growth rates (0.50 +/- 0.22), but were similar for surface and deep populations. In contrast, there was a close balance between pico-cyanobacteria growth (0.21 +/- 0.13) and grazing loss (-0.21 +/- 0.13) rates, but rates were also similar between surface and deep.
Keywords: Lake Superior, Picoplankton, Microbiological studies.

CASTANEDA, R.A. and MANDRAK, N.E., University of Toronto - Scarborough, 1265 Military Trail, Toronto, on, M1C 1A4, CANADA. **A novel detection technique for fishes at risk.**

The ability to accurately assess species abundances, distributions, and diversity is crucial for successful conservation management. However, detection of rare species presents difficulties for conservation strategies, especially when monitoring changes in population abundance. In many cases, sampling for fishes at risk, such as Redside Dace, may be restricted due to potential stress and mortality from handling in the field. The inability to sample Redside Dace reduces our ability to adequately monitor populations as required by recovery strategies and action plans. Redside Dace has been suffering an extreme population decline in response to habitat degradation with increasing urbanization; therefore, determining its distribution and abundance is of high priority. To do so, developing a new detection method that does not require physical handling of Redside Dace is required. Underwater visual analysis (UWVA), using cameras, is a passive method gaining popularity in freshwater systems. Historical Redside Dace sites at Lynde Creek, currently being affected by urbanization, were sampled in summer 2015. To calibrate the use of underwater camera images to detect and calculate Redside Dace abundance, we compare UWVA and conventional sampling (electrofishing). *Keywords: Populations, Detection technique, Fish, Conservation.*

CEVAER, A.G., MEHLER, K., BURLAKOVA, L.E., and KARATAYEV, A.Y., State University of New York at Buffalo State Great Lakes Center, 1300 Elmwood Avenue,

Buffalo, NY, 14222, USA. **Historic and Current Benthic Macroinvertebrate Community in the Niagara River.**

The Niagara River was designated an Area of Concern due to inactive hazardous waste sites, contaminated sediment, combined sewer overflows, habitat degradation, and nonpoint source pollution which impairs complete use of the river's resources. As a result, the Niagara River has been the focus of habitat restoration and remediation efforts to improve fish and wildlife habitat and to remove beneficial use impairments, including the degradation of benthos. Benthic invertebrates have been widely used as indicators in bioassessment surveys to evaluate improvements of water and habitat quality, measure the effect of invasive species on natural communities, and follow the progress of restoration projects. However, the current status of the benthic community of both the lower and upper portions of the Niagara River is lacking. The aim of our study is to compare the current benthic community with historical data to assess potential changes due to improvements in water and sediment quality. We will produce a dataset of the current benthic community characteristics and biological indicators that can be used as a baseline for long-term monitoring and to determine temporal trends. *Keywords: Species diversity, Macroinvertebrates, Niagara River.*

CHAFFIN, J.D.[1], BAER, M.M.[1], DAVIS, T.W.[2], SMITH, D.J.[3], and DICK, G.[3], [1]Ohio State University Stone Laboratory, Put-in-Bay, OH, USA; [2]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, USA; [3]University of Michigan, Ann Arbor, MI, USA. **Interactive Effects of N, P, and Light on Cyanobacteria Growth and Microcystin Production.**

Nitrogen (N), phosphorus (P), and light are known to have constraining effects on cyanobacteria growth and microcystin (MCY) production, but their interactive effects are less known. In 2014 and 2015 nutrient enrichment experiments were conducted using *Planktothrix*-laden Sandusky Bay water and *Microcystis*-laden Maumee Bay water to determine the effects of P, N form (nitrate, ammonium, or urea), N loading rate (2014) and the interaction of P, N form, and light (2015). In 2014, elevated N concentrations increased final MCY concentrations for both *Planktothrix* and *Microcystis* populations. In 2015, elevated N concentration increased MCY concentrations for *Planktothrix* but not *Microcystis*. RTqPCR analyzes are ongoing to determine MCY gene expression. For both cyanobacteria, under high light (300 umol/m2/s) and elevated N final chlorophyll concentration (CHL) was 2-3x that of control, whereas total phytoplankton biovolume (TPB) was only 1.5x that of control. However, under low light (30 umol/m2/s) and elevated N final CHL was 2-4x that of control, whereas TPB was 1.0x to 1.2x that of control. Elevated P alone did not affect MCY, CHL, or TPB in any experiment. These results highlight that MCY production begins before the subsequent growth response in Lake Erie cyanobacteria communities. *Keywords: Lake Erie, Cyanophyta, Harmful algal blooms.*

CHALLICE, A.R.[1], DUNLOP, E.S.[2], and KELLY, N.I.[3], [1]Ontario Ministry of Natural Resources and Forestry, Aurora District, 50 Bloomington Rd., Aurora, ON, L4G 0L8, CANADA; [2]Ontario Ministry of Natural Resources and Forestry, Aquatic Research and Monitoring Section, 1600 West Bank Dr., Peterborough, ON, K9L0G2, CANADA; [3]Ontario Ministry of Natural Resources and Forestry, Lake Simcoe Fisheries Assessment Unit, 26465 York Rd 18, Sutton, ON, L0E 1R0, CANADA. **Assessing the sustainability of re-opening a limited recreational fishery for Cisco in Lake Simcoe.**

The Cisco (lake herring) population in Lake Simcoe has shown considerable resiliency in the face of uncertainty since the early 2000's, resulting in the re-opening of a conservative recreational fishery that had been closed for 15 years. Although still in a state of rehabilitation, the value of this species and its unpredictably rapid resurrection as both a recreational angling opportunity, and as an indicator for aquatic ecosystem health can be demonstrated through the collaborative efforts of government and stakeholders using science-based management to guide management decisions. A brief history on the population, and the science used to assess the sustainability of re-opening the recreational fishery is discussed. *Keywords: Fish management, Lake Simcoe, Hydroacoustics.*

CHARBONNEAU, C.E. and BRADFORD, A., University of Guelph, 50 Stone Road East, Guelph, ON, N1G2W1, CANADA. **Hydrologic Analysis Supporting Green Infrastructure Design and Urban Wetland Protection.**

Wetlands depend on a dynamic hydrologic regime to support ecological function. Urban development and conventional stormwater management are altering the natural regimes of wetlands with undesirable ecological responses. Green infrastructure (e.g. permeable pavement, bioretention) promotes source control which helps to mitigate changes in catchment hydrology and the hydrologic regime of adjacent wetlands, thereby sustaining the ability of urban wetlands to provide critical ecosystem services. Research has focused on two wetlands in Pickering, Ontario where urban growth and expansion will result in development within the wetland catchments. Two years of hydrologic (surface and groundwater) data and wetland water balance analyses were used to develop a conceptual hydrological model and target hydroperiods for the subject wetlands. PCSWMM models, which incorporated the wetlands and groundwater interactions, were developed. Hydrologic modelling was used as a tool to refine the conceptual understanding of wetland processes and predict the impacts of proposed urbanization. Alternative green infrastructure systems were simulated. The simulation results provide evidence of the effectiveness of various systems to achieve identified hydroperiod targets which mitigate impacts of urbanization on the wetland and support ecosystem services. *Keywords: Wetlands, Mitigation, Modeling, Urbanization, Urban watersheds, Green infrastructure.*

CHARUSOMBAT, U.[1], LOFGREN, B.M.[2], GRONEWOLD, A.D.[2], HUNTER, T.S.[2], BLANKEN, P.D.[5], LENTERS, J.D.[3], and CHRISTOPHER, S.[4], [1]The National Academies of Science, 500 Fifth St. NW, Washington, DC, DC, 20001, USA; [2]NOAA/Great Lakes Environmental Research Laboratory, 4840 S. State Rd., Ann Arbor, MI, 48108, USA; [3]LimnoTech, 501 Avis Dr # 1,, Ann arbor, MI, 48108, USA; [4]Environment and Climate Change Canada, 135 St Clair Ave W, Toronto, ON, CANADA; [5]Department of Geography, University of Colorado, 260 ucb, Boulder, CO, USA. **Validation of lake evaporation in NOAA-GLERL's physical models.**

Evaporation, heat transfer, and energy storage within the Great Lakes water-ice-atmosphere system interact in complex ways and have a major impact on regional weather and climate over the Great Lakes basin via the atmospheric boundary layer. Several NOAA-Great Lakes Environmental Research Laboratory (GLERL) models have been used to estimate and forecast evaporation and energy exchanges over various timescales. Since 2008, the Great Lakes Evaporation Network (GLEN) has been established to measure evaporation and energy fluxes from the Great Lakes. This provides an opportunity to evaluate and tune model outputs using the observational data. The ultimate goal of this study is to improve flux and evaporation algorithms in the Weather Research and Forecasting model (WRF). However, other currently used models at NOAA-GLERL are also validated, such as the Finite Volume Coastal Ocean Model (FVCOM), a 3D ice-hydrodynamic coupled model (ICEPOM), and the Large Lake Thermodynamic Model (LLTM). Observed meteorological data from the GLEN network are used as inputs into the flux algorithms for each model. Sensitivity analysis is performed to identify the variables to which flux is particularly sensitive in the algorithm, and modifications are made based on the results of this sensitivity analysis. *Keywords: Great Lakes basin, Evaporation, Climates, Ice cover, Hydrologic budget, WRF.*

CHEN, E.S.[1] and BRIDGEMAN, T.B.[2], [1]Sylvania Northview H.S., 5403 Silica Dr, Sylvania, OH, 43560, USA; [2]University of Toledo, 6200 Bayshore Rd., Oregon, OH, 43616, USA. **Algal Concentration Reduced by Ultraviolet Light Treatment.**

Algal blooms have become a pressing issue in inland freshwater lakes on local and global scales. A plausible approach to reduce algal concentration without the use of chemical or biological agents is the use of ultraviolet light (UV). Germicidal UV is effective in eliminating algae, yet the relationships between UV intensity, algal concentrations, and mortality rates are not well understood. To quantify the mortality rates of different concentrations of *C. vulgaris* under various intensities of UV, a full factorial design of three culture densities under three UV intensities (0, 15, and 30 W) with four replications was constructed. As expected, algal concentration measured as *in situ* chlorophyll *a* decreased exponentially. With treatment of 4 hours, 52.0% (±12.2%) and 54.7% (±11.4%) of the densest culture of *C. vulgaris* was eliminated by 15 W and 30 W treatment, respectively. After 32 hours treatment, 76.7% (±11.5%) and 85.2% (±3.1%) were eliminated. Reductions in algal concentration were highly correlated with treatment time, UV intensity, and initial culture density. Our results suggest that optimal ratios of UV treatment to algal density in treated waters may be calculated to obtain a desired result such as 50% reduction or complete elimination. *Keywords: Ultraviolet radiation, Harmful algal blooms, Water quality.*

CHEN, J.[1], SHAO, C.[1], OUYANG, Z.[1], STEPIEN, C.A.[2], BRIDGEMAN, T.B.[2], CZAJKOWSKI, K.P.[2], BECKER, R.H.[2], and JOHN, R.[1], [1]Michigan State University, 1405 S. Harrison Road, East Lansing, MI, 48823, USA; [2]University of Toledo, Toledo, OH, 43606, USA. **Algal Blooms Can Turn Lake Erie to a Carbon Sink.**

The importance of inland waters in carbon cycling has only recently been recognized. The presumption that lakes are C sources had been based primarily on non-consecutive chamber measurements or ecosystem models, in which lakes may mineralize and vent to the atmosphere up to 28% of the FCO2 from the surrounding landscape. Recent investigations and field data related to the roles of phytoplankton, especially in shallow lakes, caused us to reconsider the role of lakes in the regional carbon budget. Are lakes carbon neutral or serve as an atmospheric source under various conditions or at some/all times? Our field measurements of CO2 flux (FCO2) at two eddy covariance flux towers in the Western Lake Erie Basin indicated release of 63 g C m-2 yr-1 over a 2-year study period, with 70.8±17.4 and 116.1±37.3 g C m-2 yr-1 in 2012 and 2013, respectively. Detectable relationships showed that C uptake increased with water Chl-a content over a monthly scale. There were no obvious diurnal changes in FCO2, but the basin appeared as a C sink from July through September. In addition. algal blooms appeared to cause the fluxes to switch between positive and negative. We discerned a significant effect of PAR on FCO2 when temperature was included in the model. *Keywords: Algae, Carbon cycle, Lake Erie.*

CHENG, V.[1], GUDIMOV, A.[1], ALLERTON, M.L.[1], RICHARDS, A.[2], CHOW-FRASER, P.[3], and ARHONDITSIS, G.B.[1], [1]University of Toronto Scarborough, Department of Physical & Environmental Sciences, 1265 Military Trail, Toronto, ON, M1C 1A4, CANADA; [2]Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6, CANADA; [3]McMaster University, 1280 Main St. W., Hamilton, ON, L8S 4K1, CANADA. **Towards Linking Water Level Fluctuations with Water Quality in South-Eastern Georgian Bay.**

Fluctuations in water levels affect coastal navigation, recreational activities, integrity of wetlands, and water quality. Low water levels are hypothesized to aggravate the status of Georgian Bay water quality; especially in shallow regions, where water mixing and exchange have been reduced. This in turn diminishes the dilution and assimilation of inflowing runoff and effluents from the watershed. Major water quality problems in Sturgeon Bay coincided with low water levels, yet these effects have not been quantified across the entire south-eastern Georgian Bay. We are consolidating 14 years of existing data from academic, provincial, and federal databases, to develop and validate a modeling framework that examines the effects of water level fluctuations on water quality. Geospatial models are used to characterize the degree of mixing and wind exposure. We apply our framework, across the entire South-eastern Georgian Bay to identify hot-spots with poor water quality and low water levels. Such results will help to prioritize future research and monitoring programs throughout the Bay. We also apply our methodology to inform the proposed water level regulation plan in Lake Huron and simulate management scenarios of water level fluctuations and forecast the effects of nutrient exceedances. *Keywords: Water level fluctuations, Bayesian approach, Georgian Bay, Adaptive management.*

<u>CHISHOLME, K.C.</u>[1], HATTON, J.[2], and DION, K.[3], [1]Credit Valley Conservation, Mississauga, ON, N1E3M7, CANADA; [2]Region of Peel, Brampton, ON, CANADA; [3]Toronto and Region Conservation, Toronto, ON, CANADA. **A Multidisciplinary Approach to Coastal Wetland Design.**

Filling in 26 hectares of Lake Ontario to create coastal wetland habitat in a major metropolitan area is ambitious and involved multiple agencies and approvals. This presentation will focus on the iterative design process followed by a multidisciplinary team to develop the wetland design. Integrating technical knowledge from ecologists, geomorphologists, hydraulic and hydrologic engineers, coastal engineers and construction practitioners was necessary. The end result was a design that uses innovative approaches to address the unique hydrology of coastal wetlands associated with urban tributaries in order to achieve ecological targets. The lessons learned have far reaching applications for restoring and managing coastal wetland features on the Great Lakes. *Keywords: Coastal wetlands, Restoration, Lake Ontario, Urban watersheds.*

CHOUDHURY, T.[1], ROBERTSON, W.D.[1], and FINNIGAN, D.[2], [1]University of Waterloo, 200 University Avenue W, Waterloo, ON, N2L 3G1, CANADA; [2]Ontario Ministry of Agriculture Food and Rural Affairs, Guelph, CANADA. **Use Of Woodchip Biofilters For In-Field Nutrient Treatment.**

Woodchip biofilters have been used in the treatment of nitrate from agricultural drainage systems and have proven to sustain denitrification over extended time frames (Robertson, 2010; Robertson and Merkley, 2009). However, previous studies did not look into the removal of phosphorous (P), which is the nutrient that is often responsible for eutrophication in freshwater ecosystems. Woodchips have a high permeability and porosity and a relatively high surface area and roughness. Although not generally effective in the removal of soluble-reactive P (SRP), the physical properties of woodchips could make it an appropriate media for removal of particulate P (PP), which often dominates in agricultural drainage. Three woodchip biofilters were installed near Lake Simcoe, to test the capability of woodchips in removing suspended sediment and the associated particulate P. The three sites included a vegetable washing operation, a tile drain from a sod farm and a small stream draining a corn field area. Removal rates were as high as 98% for total suspended solids and 60% for total P (TP). Almost all of the TP removal was the result of decreased PP (82% removal). *Keywords: Water quality, Nutrients, Agriculture.*

CHOWDHURY, M.[1], WELLS, M.G.[1], and HOWELL, E.T.[2], [1]University of Toronto Scarborough, Toronto, ON, M1C1A4, CANADA; [2]Ontario Ministry of the Environment and Climate Change, Toronto, ON, M9P 3V6, CANADA. **Thermocline movements cause striking variations in near-bed stratification and benthic mixing.**

The thermocline of Lake Ontario is in constant motion, and as it washes back and forth along the sloping lakebed there is a striking asymmetry in near-bed stratification and benthic turbulence between its rise and fall. Observations of the stratification and water currents from the summers of 2012 and 2013 showed that the thermocline motions had large amplitudes and a dominant period between 16-17.5 h, corresponding to a near-inertial internal Poincaré wave. During the falling phase, the warmer down-slope flow was strongly stratified with near-bed water temperature gradients of 1°C /m. In contrast during the rising phase of colder up-slope flow, there was an unstable near-bed stratification with large temperature overturns due to the shear-driven convective mechanism. Using a Thorpe-scale analysis of overturns, the inferred turbulent diffusivity during the up-slope flow was Kz $\sim 10^{-4}$ m^2 s^{-1}. In striking contrast, during the stratified down-slope flow, the turbulent diffusivities were 100 times lower. The benthic region of Lake Ontario within the thermocline swash-zone has intense biological activity. We discuss the potential biological implications of the striking variability in benthic mixing and near-bed stratification for nutrient cycling in the Lake Ontario nearshore. *Keywords: Lake Ontario, Water currents, Benthos.*

CHRISTIANSEN, D.E.[1], ROBERTSON, D.M.[2], SAAD, D.A.[2], LORENZ, D.J.[3], and LABEAU, M.B.[4], [1]U.S. Geological Survey, Iowa Water Science Center, 400 S. Clinton St., Iowa City, IA, 52240, USA; [2]U.S. Geological Survey, Wisconsin Water Science Center, 8505 Research Way, Middleton, WI, 53562, USA; [3]University of Wisconsin, Center for Climatic Research, 1225 West Dayton St., Madison, WI, 53706, USA; [4]Michigan Technological University, Dept. Civil and Environmental Engineering, 1400 Townsend Dr., Houghton, MI, 49931, USA. **Changes in Phosphorus Loading to Lake Michigan Caused by Future Changes in Land Use and Climate.**

Phosphorus (P) loading to the Great Lakes has caused many eutrophication problems. Future land-use and climate changes may modify this loading. To predict how land-use changes may affect P loading to Lake Michigan (LM), we coupled two spatially explicit models, the Land Transformation Model (LTM), and the SPAtially Referenced Regression On Watershed attributes (SPARROW) watershed model. LTM projects population to increase slightly, urbanized area to almost double, and agricultural areas to increase by ~10%. Based on SPARROW, these changes should increase P loadings by 5-10% by mid-century. To project the effects of climate change, we combined streamflow projections from the water-quantity Precipitation Runoff Modeling System (PRMS) with water quality from SPARROW. PRMS was used to project changes in streamflow throughout the LM Basin using downscaled meteorological data from 8 General Circulation Models (GCMs) with 3 greenhouse gas scenarios. GCMs project a +2.1 to +4.0 C change in air temperature and a -5.1 to + 17% change in precipitation by mid-century. These changes should cause a -21 to +8.9% change in total streamflow and a -29 to +16% change in P loading. Although the average projected changes in loadings from all of the models is small, a wide range in projections was caused by variability in projected precipitation.
Keywords: Watersheds, Nutrients, Climate change.

CHUTKO, K.[1], JAMES, A.L.[2], YAO, H.[3], and MCCONNELL, C.J.[3], [1]Dept. of Geography and Planning, University of Saskatchewan, 117 Science Place, Saskatoon, SK, S7N 5C8, CANADA; [2]Dept. of Geography, Nipissing University, 100 College Drive, North Bay, ON, P1B 8L7, CANADA; [3]Dorset Environmental Science Centre, 1026 Bellwood Acres Road, Dorset, ON, P0A 1E0, CANADA. **River Stable Water Isotope Patterns in Large Shield Basins in Northeastern and Central Ontario.**

Monitoring of stable water isotopes patterns is commonly used in the study of water cycling processes (e.g. evaporation, groundwater-surface water interactions, streamflow generation) at a variety of scales. With potential influence of both natural and human altered landscape in large basins, Gat's (2004) Isotope River Continuum Model conceptualizes the influence of processes of accumulation, water loss, recycling and mixing on the evolution of river isotope composition. For large Precambrian Shield basins like the Sturgeon River-Lake Nipissing-French River (SNF) and the Muskoka River basins both located in the headwaters of Georgian Bay in northeastern and central Ontario, river stable water isotope patterns may reflect a range of influences, including summer-time evaporative enrichment due to large surface water storage. The objective of this study is to use stable water isotopes to provide insight into water cycling processes, including streamflow generation and effects of surface water storage within these two basins. This paper will present several years of precipitation and river stable water isotope patterns collected from 16 river catchments (27-6887 km^2) in the SNF basin, and compare to observations collected from a mix of small and large catchments in the Muskoka basin. *Keywords: Hydrologic cycle, Watersheds, Stable isotopes.*

CIBOROWSKI, J.J.H.[1], KOVALENKO, K.E.[2], ANGRADI, T.[3], BARTON, D.R.[4], BHAGAT, Y.[2], BRADY, V.J.[2], CAI, M.[2], KREIGER, K.J.[5], BOWMAN, M.F.[1], SMITH, S.D.P.[6], ALLAN, J.D.[6], and JOHNSON, L.B.[2], [1]University of Windsor, 401 Sunset Avenue, Windsor, ON, N9J 3C1, CANADA; [2]Natural Res. Inst., University of Minnesota Duluth, Duluth, MN, USA; [3]US Environmental Protection Agency, Duluth, MN, USA; [4]University of Waterloo, Waterloo, ON, CANADA; [5]Heidelberg University, Tiffin, ON, USA; [6]University of Michigan, Ann Arbor, MI, USA. **Zoobenthic Indicators of the Condition of Lake Erie and the Great Lakes Nearshore.**

A challenge of developing and calibrating indicators using the Reference Condition Approach is to suitably define the bounds of the reference condition within which to sample and against which to assess test sites. Alternatively, one can calibrate indices by sampling across the full range of environmental stress, ordinate effects (response) variables against the gradient and identify the changing range of variability in the response variables. We created a composite stressor gradient by combining Great Lakes Environmental Assessment & Mapping (GLEAM) stress layers likely to influence zoobenthos. We then examined variation in zoobenthic composition from two datasets - the 2004 L. Erie Comprehensive Collaborative Study (ECCS; benthos from 294 stratified-randomly located stations), and EPA's 2010 National Coastal Condition Assessment (40-60 nearshore stations/Great Lake). We performed TITAN analysis for zoobenthos to infer reference & degraded stress thresholds. Subsequently, habitat-specific (depth, substrate) indices were derived, relating changing community composition to the stress gradients. Hexagenia mayflies, gammarid amphipods, and oligochaetes/chironomids characterized reference condition of shallow-soft (western basin), shallow-hard, and deep-soft habitat locations, respectively, validated with 2010 & 2015 survey data. *Keywords: Benthos, Bioindicators, Biomonitoring.*

CLINE, M.T.[1], BECKER, R.H.[1], LEKKI, J.[2], BRIDGEMAN, T.B.[1], TOKARS, R.[2], and ANDERSON, R.[2], [1]University of Toledo, 2801 W Bancroft St, Toledo, OH, 43606, USA; [2]NASA Glenn Research Center, 21000 Brookpark Rd, Cleveland, OH, 44135, USA. **Analysis of Coincident HICO and Airborne Hyperspectral Images Over Lake Erie Western Basin HABs.**

Harmful algal blooms (HABs) produce waterborne toxins that pose a significant threat to people. 40 million people in Canada and the U.S. depend on Great Lakes water. In the summer of 2014, in the Lake Erie Western Basin, an HAB of the cyanobacteria Microsystis was so severe that a water-use ban was issued for Toledo, Ohio, affecting 400,000 people. We investigated bloom intensity, composition, and spatial variability by comparing coincidental hyperspectral data from NASA's HICO, and NASA GRC's HSI airborne sensor, with on-lake ASD radiometer measurements and in situ water quality testing as ground reference data. Coincident data sets were obtained with HICO on one day in 2014, all other data sets coincide 4 times in 2015. Remote sensing data were atmospherically corrected using the empirical line method. Cyanobacteria Index (CI) images were created from processed images using the Wynne (2010) algorithm, previously used for MODIS and MERIS imagery. This algorithm-generated CI images provide reliable results for both ground level (R^2=0.921), airborne (R^2=0.7981), and satellite imagery (R^2=0.7794) for seven sampling points. First and second order derivatives of the spectra were analyzed to identify abundance of in water constituents. Remotely analyzing HABs can be a cost- and time-effective tool for HABs analysis. *Keywords: Remote sensing, Hyperspectral, Algae, Lake Erie.*

COBER, J.R.[1], MACRAE, M.L.[1], VAN EERD, L.L.[2], and O'HALLORAN, I.P.[2], [1]Dept. of Geography and Environmental Management, University of Waterloo, Waterloo, ON, CANADA; [2]School of Environmental Sciences, University of Guelph Ridgetown Campus, Ridgetown, ON, CANADA. **Impact of Freeze-Thaw Cycle Magnitudes on the Release of Phosphorus From Cover Crops.**

The use of cover crops is a best management practice (BMP) that has been employed to reduce nutrient losses in agricultural runoff. However, there is potential for cover crops to enhance losses of dissolved reactive phosphorus (DRP) following freeze-thaw cycles (FTC). We examined (1) the impact of FTC magnitude on water extractable phosphorus (WEP) pools; (2) if DRP release varied with crop type; (3) if DRP release varied between vegetation that was living or dead at the time of freezing. Five species (cereal rye, red clover, oilseed radish, hairy vetch, and oat) were exposed to five days of FTC at a range of magnitudes (4 °C, -4 to 4 °C, -18 to 4 °C, and -18 to 10 °C). WEP concentrations from vegetation were significantly higher when exposed to -18 °C temperature and were not affected at -4 °C. The magnitude of P loss under very cold temperatures was larger for radish and oats, but not for

clover or vetch. Termination (by spraying) increased WEP pools in all five species, and did not differ across the FTC magnitude treatments. Thus, cover crop selection and management, as well as temperature greatly influenced WEP, which may have implications for cover crop use in the Great Lakes region. *Keywords: Phosphorus, Agriculture, Biogeochemistry, Nutrients.*

COLBORNE, S.F., HALFYARD, E.A., KESSEL, S.T., and FISK, A.T., Great Lakes Institute for Environmental Research, University of Windsor, 401 Sunset Ave., Windsor, ON, N9B 3P4, CANADA. **Using Acoustic Telemetry to Monitor Bowfin and Largemouth Bass in the Detroit River.**

The Detroit River is not only a physical connection between Lakes Huron and Erie, but is itself an ecologically diverse ecosystem with numerous resident and migratory species utilizing its various habitats. In response to anthropogenic impacts on this ecosystem there are international efforts to protect and restore the river, but their success requires an understanding of how species use the river. Habitat use of fish can be monitored passively using acoustic telemetry to track animal movements over extended periods of time. During 2015 we established a gridded acoustic telemetry array along Fighting Island and implanted 69 kHz tags (VEMCO Ltd.) into two of the most common piscivore predators from this section of the river, Bowfin (*Amia calva*) and Largemouth bass (*Micropterus salmoides*), and monitored their fine scale two-dimensional movements from June - October 2015. Additionally, this project is tied into the GLATOS (Great Lakes Acoustic Telemetry Observation System) network providing broader scale coverage of movement in the Great Lakes region. The movement and habitat use patterns of Bowfin and Largemouth bass generated by this project will provide ecological information about these two predator species in the unique Detroit River ecosystem and provide information applicable to ongoing conversation efforts *Keywords: Acoustics, Detroit River, Fish tagging.*

COLE, S.J.[1], DORAN, P.J.[2], SOWA, S.P.[2], MOLNAR, S.[1], and WEIS, S.[2], [1]Great Lakes Commission, 2805 S. Industrial Hwy Suite 100, Ann Arbor, MI, 48104, USA; [2]The Nature Conservancy Michigan Chapter, 101 East Grand River Ave, Lansing, MI, 48906, USA. **Great Lakes Blue Accounting - Collaborating on Shared Goals and Metrics.**

Great Lakes institutions are investing heavily in programs to maintain the Great Lakes as a healthy natural resource that also supports human uses and economic activity but there is no region-wide view of the progress we're making towards our shared goals. Our governors, premiers and federal agency leaders don't have the information they need to make good decisions: to set priorities and allocate resources to achieve these shared goals.

That's why the Great Lakes Commission and The Nature Conservancy have teamed up to develop Blue Accounting, an information service that will help Great Lakes leaders understand the progress we're making towards our goals and keep us moving in the right direction. Over the next five years, we will establish collaboratives for three pilot issues. They will measure our progress in delivering safe drinking water, removing barriers from streams, and defending the lakes against invasive species. These collaboratives will emphasize the centering of metrics as a key tool to create shared goals and measure progress against those goals. A Blue Accounting information system will enable collaboration and deliver metrics to decisionmakers. *Keywords: Decision making, Policy making, Planning, Collaboration, Management, Information management.*

COLLIER, K., ROZMARYNOWYCZ, M.J., BULLERJAHN, G.S., and MCKAY, R.M., Bowling Green State University, Bowling Green, OH, 43403, USA. **Microbial Community Partitioning Between Ice and Water During Winter in Large Lakes.**

There is growing recognition that winter can be an important, albeit poorly documented, season for growth of photoautotrophic organisms in ice-covered freshwater environments. Abundant phytoplankton and bacteria were identified by high-throughput 16S- and 18S rDNA tag Illumina sequencing of samples from water and ice phases collected during winter 2015 from Lake Erie as well as two inland lakes in Ohio. The centric diatom *Aulacoseira islandica* was identified from both ice and water at sites in Lake Erie's central basin. Among heterotrophic phyla, reads of *Betaproteobacteria* were uniformly dominant in water whereas *Gammaproteobacteria* appeared to be preferentially partitioned to ice. At inland lakes, cryptomonads were dominant in water whereas dinoflagellates partitioned to ice. Photosynthetic characterization of photoautotrophs resident in water and ice showed that communities from both phases were active, thus supporting ice as viable habitat for phytoplankton in freshwater lakes. *Keywords: Ice, Phytoplankton, Lake Erie.*

COLLINGSWORTH, P.D.[1] and WARREN, G.J.[2], [1]Purdue University, Department of Forestry and Natural Resources, 715 W. State Street, West Lafayette, IN, 47907, USA; [2]EPA Great Lakes National Program Office, 77 W. Jackson Blvd, Chicago, IL, 60604, USA. **Trends in total phosphorus and chlorophyll in Lake Erie: insights from two monitoring programs.**

The EPA Great Lakes National Program Office (EPA-GLNPO) has operated a continuous monitoring program focused on offshore waters throughout the Great Lakes since the early 1980's. One common critique of this program is that the EPA-GLNPO monitoring program lacks the temporal resolution necessary to characterize seasonal nutrient

trends, particularly in a dynamic system such as Lake Erie. To supplement the EPA-GLNPO monitoring program the Lake Erie Committee Lower Trophic Level Task Force (LEC-LTLF) has operated monitoring program since the late 1990's. The LEC-LTLF monitoring program is focused in nearshore areas and samples are collected bi-weekly. Here, we compare trends in total phosphorus and chlorophyll in Lake Erie using data collected by both programs to provide a more complete picture of lower trophic level dynamics in the system. Our results indicate that increasing the temporal resolution of sampling introduces significant variation to the lower trophic level time series, particularly in the shallow western basin of Lake Erie and during the spring. *Keywords: Lake Erie, Monitoring, Nutrients.*

COLLIS, L.M.[1], GEORGE, E.G.[1], HARE, M.P.[1], LANTRY, B.[3], CRABTREE, D.L.[2], and RUDSTAM, L.G.[1], [1]Cornell University, Department of Natural Resources, 110 Fernow Hall, Ithaca, NY, 14853, USA; [2]The Nature Conservancy of New York, 1048 University Avenue, Rochester, NY, 14607, USA; [3]USGS Lake Ontario Biological Station, 17 Lake St, Oswego, NY, 13126, USA. **Diet Analysis of Larval Cisco (*Coregonus artedi*) in Chaumont Bay, Lake Ontario.**

The life history of cisco (*Coregonus artedi*) in Lake Ontario is not well understood, due in part to the species' near extirpation from the lake in the 1950s. Understanding the feeding ecology of larval cisco is crucial to discerning this native fish's early life history and promoting future restoration success. Larval cisco were collected from Chaumont Bay, Lake Ontario in April and May of 2014 and their stomach contents examined for diet analysis. Diets were analyzed for species composition, total prey biomass, and average prey length and width over time. Corresponding zooplankton tows were collected on larval sampling occasions to determine prey selectivity. Gape measurements were calculated based on larval length to determine if cisco prey selection was influenced by gape limitation. The time and size at which larval cisco switched from endogenous to exogenous feeding was also considered. The results of this diet analysis will contribute to a more thorough understanding of larval cisco feeding habits in the Great Lakes and enhance future coregonine restoration planning and efforts. *Keywords: Lake Ontario, Larval fish, Diets, Cisco, Fisheries, Lake herring.*

COMEAU, G. and KIRKWOOD, A.E., University of Ontario Institute of Technology, 2000 Simcoe St.N., Oshawa, ON, L1H7K4, CANADA. **Periphyton Community Structure along Rural-Urban Gradients in Lake Ontario Tributaries.**

Increased urbanization has led to the fragmentation of landscapes creating complex rural-urban gradients. The shift from rural to urban land-use can affect the physical, chemical and biological characteristics of stream ecosystems. To understand the temporal and spatial variability of nutrient inputs and water quality impacts from the rural-urban landscape mosaic, our study examined 4 main-stem tributaries in discrete Durham Region watersheds that share similar physiographic features, but different gradients in rural-urban land-use transition and intensity. By comparing matched sites in distance-from-headwaters, we could determine the relative importance of rural-urban land-use on nutrients and water quality both laterally and longitudinally. Though water quality variables and algal community composition highly varied among tributaries, some significant trends in conductivity and nutrients indicated shifts in land-use. Dominant taxa included pollution tolerant genera such as Achnanthidium, Gomphonema and Diatoma. The high abundance of these pollution tolerant genera could be indicative of cumulative impacts unique to rural-urban land-use gradients. On-going analyses aim to delineate community shifts associated with changing water quality profiles influenced by changing land-use type and intensity. *Keywords: Periphyton, Land-use, Tributaries, Water quality, Watersheds, Urbanization.*

CONFESOR, R.B.[1], KALCIC, M.[2], LOGSDON, R.M.[2], SCAVIA, D.[2], ALOYSIUS, N.R.[3], ARNOLD, J.G.[4], ATWOOD, J.[4], BOLES, C.[5], DEPINTO, J.V.[5], GILDOW, M.[3], MARTIN, J.[3], REDDER, T.M.[5], ROBERTSON, D.M.[6], SOWA, S.P.[7], WHITE, M.J.[4], and YEN, H.[8], [1]Heidelberg University, 310 E Market St., Tiffin, OH, 44883, USA; [2]University of Michigan Graham Sustainability Institute, Ann Arbor, MI, USA; [3]The Ohio State University, Columbus, OH, USA; [4]United States Department of Agriculture - Agricultural Research Service, Temple, TX, USA; [5]LimnoTech, Ann Arbor, MI, USA; [6]United States Geological Survey, Middleton, WI, USA; [7]The Nature Conservancy Great Lakes Project, Lansing, MI, USA; [8]Blackland Research & Extension Center, Texas A&M University, Temple, TX, USA. **Achieving Nutrient Load Reduction Targets in the Western Lake Erie Basin: A Multi-Model Approach.**

The 2012 Great Lakes Water Quality Agreement between the United States and Canada calls for a revised nutrient loading reduction target to minimize Harmful Algal Blooms (HABs) occurrence in the Western Lake Erie Basin (WLEB). Current evidence indicates that the Maumee River watershed (MRW) is a major source of nutrients that trigger cyanobacterial blooms in the WLEB. The agriculturally-dominated MRW delivers about 5% of the water and 48% of the total phosphorus into Lake Erie but accounts for one-fifth of the lake's drainage area. It is not surprising then that the MRW has been recently the focus area in reducing nutrient exports to WLEB. A multi-model approach using five SWAT models and one SPARROW model was undertaken to help identify potential solutions for reducing nutrient exports from the MRW agricultural lands. This approach took account of the different assumptions in the models' setup and calibration. Maximum implementation of best management practices (BMPs; e.g., 100% no-till, subsurface fertilizer application, etc.) as well as "optimal" implementation of BMP suites were run through the models. The uncertainties in model outputs were also estimated. The results of this study would help guide policymakers and stakeholders achieve the target load reductions in Lake Erie. *Keywords: Harmful algal blooms, Best management practices, Nutrients, Watershed, Modeling, Load reduction.*

CONNELLY, N.A., LAUBER, T.B., NIEDERDEPPE, J., and KNUTH, B.A., Cornell University, Ithaca, NY, 14853, USA. **Adherence to Fish Consumption Advisories by Urban Anglers in the Great Lakes Region.**

Consuming fish provides important health benefits, but consuming too much contaminated fish is associated with increased risks of cancer and neurological deficits. Urban areas often have higher levels of contaminants in fish, and urban anglers of limited means may be more restricted to urban fishing sites and more dependent on fish they catch for food. The Great Lakes Consortium for Fish Consumption Advisories has made an ongoing, long-term effort to encourage urban anglers to eat fish within recommended limits. Working with the Consortium, we conducted a diary study in the summer of 2014 to examine the fish consumption patterns of urban anglers in three communities (Kalamazoo, MI; Erie, PA; Rochester, NY) within the Great Lakes region. We assessed their adherence to the recommendations issued by their state of residence. The results show significant variation between locations in types of fish consumed and adherence to the advice (7-40%). Rochester anglers were more likely to exceed the recommendations by consuming too much channel catfish and larger trout, whereas Kalamazoo and Erie anglers were more likely to consume too much walleye. We will discuss likely causes of the variations, and make recommendations for increasing compliance. *Keywords: Great Lakes Restoration Initiative (GLRI), Urban areas, Human health.*

CONNOLLY, J.K., WATKINS, J.M., and RUDSTAM, L.G., Cornell University, Department of Natural Resources, 110 Fernow Hall, Ithaca, NY, 14853, USA. **An assessment of Laurentian Great Lakes rotifer communities.**

Rotifers are microscopic invertebrates inhabiting nearly all freshwater environments including pelagic areas of the Great Lakes and serve an important intermediary role within the aquatic food web. In lakes rotifers have also been used as trophic indicators as rotifer community composition and abundance appears to vary relative to trophic state (Gannon and Stemberger 1978). Due to the food web interactions that rotifers facilitate as trophic indicators, rotifers are an important component of long-term monitoring programs. However, the challenging and labor-intensive nature of rotifer taxonomic identification can be a barrier to integrating rotifers into biological assessments. The advent of new benchtop imaging and particle counting technologies such as the FlowCam may automate rotifer processing to some degree, but its utility for identifying rotifers has not yet been fully developed. In this study, rotifer samples were collected using 64 micron mesh nets from pelagic areas of all five of the Great Lakes. Subsamples were counted manually by a trained taxonomist and also processed using a FlowCam. The resulting image library and size measurements were evaluated to determine the viability of the FlowCam in future rotifer processing and biomonitoring efforts. *Keywords: Zooplankton, Monitoring, Biomonitoring.*

CONROY, J.D.[1], ZWEIFEL, R.D.[1], BRILAND, R.D.[2], MOODISPAW, C.F.[2], and ANDERSON, R.M.[2], [1]Inland Fisheries Research Unit, Division of Wildlife, Ohio Department of Natural Resources, Hebron, OH, USA; [2]Aquatic Ecology Laboratory, Department of Evolution, Ecology, and Organismal Biology, The Ohio State, Columbus, OH, USA. **Development of a rapid zooplankton assessment tool for fisheries research and management.**

Sportfish are stocked as either fingerlings (about 25-mm total length) or fry (about 7 mm), sizes particularly sensitive to zooplankton forage availability. Zooplankton biomass, community composition, and size have all been found previously to affect the success of sportfish recruitment. However, determining these zooplankton community characteristics relies on detailed microscopic determinations, requiring skilled technicians and several hours per sample to process. Here, we sought to decrease the time and skill needed to quantify total zooplankton biomass at the time of stocking juvenile, obligate planktivore sportfish by comparing microscope-based zooplankton biomass estimates with those determined gravimetrically. To compare biomass determination methods, we collected zooplankton samples (n = 94) from 18 Ohio reservoirs at the time of *Sander* spp. stocking and estimated dry biomass both microscopically (MicroB) and gravimetrically (GravB). We found a linear relationship between log-transformed biomasses (MicroB = 0.076 + 1.286 x GravB) which explained a large amount of the total variation (r2 = 0.627). Rapid, gravimetric determinations of zooplankton biomass is a new approach that provides fisheries professionals a ready tool for "quick and dirty" assessments. *Keywords: Fish management, Monitoring, Zooplankton.*

COOKE, M.A.[1], KUSHNER, P.J.[1], and MACINTYRE, S.[2], [1]Department of Physics, University of Toronto, Toronto, ON, CANADA; [2]Department of Ecology, Evolution, and Marine Biology, University of California at Santa Barbara, Santa Barbara, CA, USA. **Linking large-scale weather patterns with small-scale mixing variability in an Alaskan Arctic lake.**

As surface temperatures increase, some lakes may become more stably stratified and produce less vertical mixing, inhibiting biological productivity. While surface temperature may increase lake stability, periods of mixing can still be initiated by weather events. Summertime lake and meteorological data from Toolik Lake, Alaska, sampled at a high frequency for over a decade, were used to study the interannual variability of lake mixing in the rapidly-changing Arctic. We systematically identified mixing events for 12 summers, using criteria based on low lake number and on the deepening of the seasonal thermocline. To tie the mixing variability to weather variability, we first used cluster analysis of an atmospheric reanalysis product to identify the dominant weather regimes surrounding Toolik Lake. We then found two distinctive weather regimes that coincided most frequently with mixing events. One featured a low pressure center over the Arctic Ocean and the passage of a cold front. At Toolik Lake, this regime produced strong winds, cold epilimnetic temperatures, and mixing of heat into the hypolimnion. The other regime featured a ridge over Arctic Alaska and high pressure over the Arctic Ocean. At Toolik Lake, this regime produced strong winds, warm or moderate epilimnetic temperatures, and mixing of heat into the metalimnion. *Keywords: Arctic, Mixing, Climate change, Climatology.*

COOKE, S.E., 400 Clyde Road, P.O. Box 729, Cambridge, On, N1R 5W6, CANADA. **Multi-agency Implementation of the Grand River Water Management Plan.**

Many agencies in Ontario share responsibility for water management. The Grand River watershed, the largest in southern Ontario draining to the eastern basin of Lake Erie, faces many challenges: population growth, extensive agriculture and a changing, more variable climate. Cross-agency solutions are required to address these complex issues. Consequently, many agencies involved in water management came together to address challenges and updated the Water Management Plan for the watershed. Sixteen partners endorsed the water management plan in 2014 and committed to implement their actions listed in the Integrated Action Plan. The Grand River Conservation Authority (GRCA) acts as the backbone agency to help facilitate quarterly meetings and dialogue among partners for shared learning. An annual 'Report on Actions' is compiled for the collective reporting out on the progress of implementing 163 actions that partners have agreed to implement. Indicators are being explored for reporting on the collective partnership and coordination of Plan implementation as well as the state of water management to achieve the goals of the Plan. This paper will highlight the current governance framework in place that facilitates shared learning among Plan partners, share some of the early wins and highlights some of the on-going challenges. *Keywords: Grand River, Governance, Watersheds, Implementation, Indicators.*

CORBIERE, M.M. and TORBICK, N.T., Applied Geosolutions, 55 Main Street, Newmarket, NH, 03857, USA. **Multiscale Mapping of Lake Champlain Algal Blooms.**

Cyanobacterial harmful algal blooms (CHABs) in Lake Champlain pose a risk to public health. Remote sensing can help track these blooms to support risk decision making and provide a quick warning system for the public. Landsat 8, Rapid Eye, and Proba CHRIS high resolution images were obtained corresponding to in situ measurements of water quality. Regression models were applied to map chlorophyll-a and phycocyanin concentrations; all sensors performed well with R^2 and root-mean-square error (RMSE) ranging from 0.76 to 0.88 and 0.42 to 1.51, respectively. To complement the high spatial resolution assessment, we integrated high temporal frequency mapping using MERIS and created alert status frequency maps. The optimal model had an out-of-sample R^2 of 0.71 and RMSE of 1.15. Missisquoi Bay, St Albans Bay, and a few other areas were identified as hot spots with chronic CHAB events in the past decade. Among the sensors utilized in this study, Landsat 8 holds the most promise for operational monitoring of algal blooms across a wide area given the resolution, temporal frequency, and free cost. The multiscale maps were tuned to Champlain's current, tiered monitoring protocol to illustrate how remote sensing can inform a public health monitoring system and complement traditional sampling.
Keywords: Harmful algal blooms, Decision making, Remote sensing, Modeling.

CORCORAN, P.L., University of Western Ontario, 1151 Richmond St. N., London, On, N6A5B7, CANADA. **Microplastics as global markers of the Anthropocene.**

The interaction between humans and Earth's natural systems has resulted in scattered and buried byproducts across the globe. Some of these have the potential to become incorporated into the geologic record, but none are as globally persistent and as resistant to degradation as plastic. Although there is a positive relationship between plastics abundance and urban centres, plastic debris has also been reported from regions as remote as Iceland and Antarctica. The Great Lakes of North America are no exception. Recent studies have shown that microplastics are abundant in bottom sediment of Lake Ontario and Lake Erie. These microplastics are prone to preservation, as they are shielded from photo oxidation and mechanical erosion, processes that work to degrade polymers. Once covered by sediment and an overlying water column, microplastics have the potential to become part of a global, plastic stratigraphic horizon marking the currently informal Anthropocene epoch. Examples of plastic marker horizons have been unearthed in regions where excavation has occurred for the purposes of erecting structures and installing water systems. Combining the plastic debris found in aquatic-related habitats with those that are regularly deposited into landfills results in plastics being the most widely distributed anthropogenic markers on Earth. *Keywords: Microplastics, Geoarcheology, Environmental contaminants.*

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

The St. Clair Detroit River System (SCDRS) is utilized by fish for reproduction, as a conduit for transport of larvae, and as a nursery habitat. This Laurentian Great Lakes connecting channel has a history of environmental degradation and recent restoration efforts. Larval fish are sensitive to environmental degradation and may respond to habitat improvement. Limited analyses of larval fish diets and growth rates in the SCDRS have been conducted. Our objective was to assess the growth and diet of larval lake whitefish relative to other species across time and among habitats in the SCDRS. Larval fish specimens were collected from the SCDRS from 2005 to present. Larval growth rates were determined by relating total length to age as measured using otolith analysis. We dissected stomachs to quantify diet composition and calculated selectivity relative to ambient zooplankton composition. Our analysis of larval fish diets, and determination of spatial and temporal variability within larval fish communities, provides information on the trophic ecology of this system. Understanding larval fish use of the SCDRS main channel will aid in providing recommendations for future restoration projects and management plans for the waterway. *Keywords: Lake Huron, Detroit River, Lake St. Clair, Lake Erie, Fish diets, St. Clair-Detroit River System.*

CREED, I.F.[1], LAURENT, K.L.[1], FRIEDMAN, K.F.[2], and CORMIER, R.[3], [1]Western University, Canada, 1151 Richmond Street, London, ON, N6A 5B7, CANADA; [2]University at Buffalo School of Architecture and Planning, Regional Institute, SUNY at Buffalo, 77 Goodell Street, Suite 302, Buffalo, NY, 4203, USA; [3]Zentrum für Material- und Küstenforschung GmbH Institute for Coastal Research, Max-Planck Straße 1, Geesthacht, 21502, GERMANY. **The use of formal science management integration systems to manage risk in the Great Lakes.**

The Great Lakes have a rich history of diverse policy instruments and management tools that have been employed by governments on both sides of the Canada-U.S. border to protect the critical freshwater resource. However, the Great Lakes continue to show signs of degradation. We explore how governments can reduce the risk of failing to achieve policy objectives regarding the Great Lakes through the application of the International

Organization for Standardization Risk Management Standard (ISO 31000). ISO 31000, and its analysis tools such as the IEC/ISO 31010 Bowtie Analysis, facilitates the analysis of anthropogenic activities that drive the causal pathways of ecosystem pressures-effects-impacts, while also analyzes the links between these causal pathways and the performance of management measures operating within the Great Lakes. ISO 31000 allows governments to shed light on why, despite best intentions, management measures are not working. As a result, governments are able to continually improve the management system until the risks of policy failures are reduced to acceptable levels, bringing new hope to the future of the Great Lakes. *Keywords: Political aspects, Great Lakes, Management, ISO 31000, Risks, ISO 31010.*

CRUZ-FONT, L.[1], HLEVCA, B.[1], WELLS, M.G.[1], MIDWOOD, J.D.[3], COOKE, S.J.[2], ROUS, A.M.[2], DOKA, S.E.[3], and GUTOWSKY, L.F.G.[2], [1]University of Toronto Scarborough, Toronto, ON, CANADA; [2]Carleton University, Ottawa, ON, CANADA; [3]Department of Fisheries and Oceans, Burlington, ON, CANADA. **Thermal Biology Explains Fish Behaviour During Upwelling Events in a Large coastal Embayment.**

The thermal tolerance of different fish species can be challenged when environmental disturbances suddenly change the water temperature. Upwelling events, for example, reduce water temperatures by several degrees over just a few hours providing fish only a short time to adapt. We expect species to react differently to this thermal disturbance, with warm-water fish being more impacted by rapid cooling. We tested the rate of change in fish depth and fish body temperature compared with the rate of change in water temperature. We used acoustic telemetry to track largemouth bass (*Micropterus salmoides*) and northern pike (*Esox lucius*) in the embayments of Toronto Harbour, coupled with detailed water temperature information. In general, fluctuations in internal fish temperature were related to changes in water temperature. However, this link was not always maintained during upwellings since fish tended to stay in shallow waters where the cooling effects from upwellings were less extreme. There was variation in the observed behaviour between species and within species, but overall largemouth bass exhibited smaller rates of changes compared to northern pike. These results are applicable to the local plans of habitat restoration. *Keywords: Fish tagging, Lake Ontario, Coastal ecosystems.*

CURRIE, W.J.S.[1] and WATKINS, J.M.[2], [1]Fisheries and Oceans Canada, 867 Lakeshore Rd, Burlington, ON, L7S1A1, CANADA; [2]Cornell University Biological Field Station, 900 Shackelton Point Rd, Bridgeport, NY, 13030, USA. **A living e-doc on Great Lakes emerging technologies.**

The term *emerging technologies* within science has been used to describe the application of innovative measurement tech to a new system where data has been historically collected

using traditional methods, or not been collected previously. Location can be new, or the technology can be new. Data may be collected on more extensive spatial or temporal scales and/or higher resolutions. Recent advances in robotics, optics, satellites, chemistry, deployable cameras, data streaming, sharing and visualization are all examples which can advance scientific research. Many of these technologies are new to freshwater research, having been used in oceanography for many years, though this pattern is changing. We will outline some results from emerging technologies applied to the 2013 Lake Ontario Coordinated Science and Monitoring Initiative (CSMI), but some technologies have focused only on certain lakes, and all of the Great Lakes can benefit from these and other state-of-the-art methods. We propose to detail these in a new class of research document: a living e-doc that will illustrate the application and merit of emerging technologies for use in Great Lakes research. This will exist in electronic form, not limited to traditional text and figures, but will also include embedded video demonstrations and data-files. *Keywords: Measuring instruments, Remote sensing, Observing systems.*

CURRIER, C.A.[1], RIDGWAY, M.[2], MORRIS, T.J.[3], WILSON, C.C.[2], and FREELAND, J.R.[1], [1]Trent University, 1600 W Bank Dr, Peterborough, ON, K9L 0G2, CANADA; [2]Ministry of Natural Resources & Forestry, 1600 West Bank Dr., Peterborough, ON, K9L 0G2, CANADA; [3]Fisheries and Oceans Canada, 867 Lakeshore Rd., Burlington, ON, L7S 1A1, CANADA. **Detection Probabilities of Environmental DNA (eDNA) and Traditional Sampling for Unionid Mussels.**

Environmental DNA (eDNA) detection is a growing field in which species-specific markers are used to screen DNA from bulk samples such as water to infer species presence. With this rapid growth, it is becoming increasingly important to quantify detection probabilities and limits of eDNA assays. Furthermore, before eDNA can be widely applied for research or monitoring, it will be important to evaluate the probabilities of detecting species from eDNA compared to those of more traditional sampling methods. This study builds on previous work that developed and tested species-specific qPCR markers for four freshwater pearly mussels (Unionidae). Here, the markers were applied to water samples from field sites that had previously been intensively sampled using a quadrat design. This paired design allowed us to compare species occupancy estimates and generate detection probabilities for each sampling method at identical sites. For species-at-risk in particular, widespread use of a sampling method with low detection rates could lead to devastating outcomes; a thorough knowledge of the detection thresholds and limitations of eDNA assays is crucial for accurate interpretation of results and subsequent management applications. *Keywords: Biodiversity, Environmental DNA, Genetics, Mussels.*

CZESNY, S.J.[1], HAPPEL, A.[1], RINCHARD, J.[2], and STAFFORD, C.[3], [1]University of Illinois/INHS/Lake Michigan Biological Station, 400 17th Street, Zion, IL, 60099, USA; [2]The College at Brockport - State University of New York, 350 New Campus Drive, Brockport, NY, 14420, USA; [3]University of Montana, 32 Campus Drive, Missoula, MT, 59812, USA. **Fatty acid profiles of lake trout reveal variability in trophic connections across spatial scale.**

As an indirect method of diet analysis, fatty acid profiles have quickly garnered much interest by ecologists. However, interpretations of trophic connections from fatty acids may differ depending on tissue type and its lipid content. To investigate differences between tissues sampled, muscle plugs and belly flaps were taken from lake trout caught in Lakes Champlain, Ontario, Michigan, Swan, and Flathead. Fatty acid profiles of each tissue were used to evaluate foraging differences among lake trout populations. Tissue specific fatty acid profiles were most similar when lipid content of muscle samples was >10 %, similarities dropped precipitously below this level. In general, fatty acid profiles were specific to each lake, indicating that food web structure was distinct in each lake. Fatty acid profiles indicated that lake trout from Lake Champlain were highly piscivorous, compared to similarly size fish from other lakes. Indicators of bacterial trophic connections were higher in lake trout from Lake Ontario than other lakes. Tissues of higher fat content (i.e. adipose) likely offer greater insights into dietary changes vs. tissues of greater membrane concentrations (i.e. muscle). Further investigations linking fatty acids to diets of species across spatially disparate systems could greatly enhance trophic indicator development. *Keywords: Predation, Fatty acids, Diets, Lake trout.*

D

DAHER, H.[1], GRONEWOLD, A.D.[2], SMITH, J.P.[2], BOLINGER, R.A.[2], and ROOD, R.B.[1], [1]University of Michigan Climate and Space Sciences and Engineering, 2455 Hayward St., Ann Arbor, MI, 48109, USA; [2]NOAA-GLERL, 4840 S. State St., Ann Arbor, MI, 48108, USA. **Climate as a Driver of Regional Ice Cover.**

Over the past several decades there has been a documented decrease in the areal extent of winter ice cover on the Laurentian Great Lakes. Differentiating drivers of decreasing ice cover, as well as drivers of interannual variability, is critical to regional interests, particularly in light of the significant spatial heterogeneity of ice cover across the lake surfaces. Previous research has shown that winter conditions on the Great Lakes, including but not limited to ice cover, respond to climate patterns (e.g. teleconnections), but these studies have focused primarily on coarse temporal (e.g. seasonal maximum) and spatial (e.g. basin-wide) scales. Here, we explore relationships between teleconnections and seasonal

ice cover in Western Lake Superior, within and surrounding the Apostle Islands National Lakeshore. Our analysis focuses on identifying climate indices that provide strong explanations for observed ice cover variability. We find that a small subset of monthly climate indices provide a strong indication of monthly and seasonal ice cover in the area surrounding the Apostle Islands in the following winter. Relationships between these climate indices and ice cover patterns on even finer spatial and temporal scales that may provide guidance to management planning decisions are not as well defined.

DANIEL, S.E., BURLAKOVA, L.E., and KARATAYEV, A.Y., Great Lakes Center, SUNY Buffalo State, 1300 Elmwood Avenue, Buffalo, NY, 14222, USA. **The effect of *Dreissena* on vertical distribution and abundance of Oligochaeta in Lake Erie.**

The effect of *Dreissena* on profundal Oligochaeta has been largely understudied. However, it has been suggested that dreissenids, through their feeding and filtering activities, may promote certain species of oligochaete by enhancing the deposition of organic material, as well as inhibit other species through mechanisms that are not yet completely understood. We compared Oligochaeta density, biomass, and species composition from samples with high and low *Dreissena* density using data obtained from the EPA long-term monitoring program, as well as data collected in CSMI study of Lake Erie in 2014. We also studied the effect of *Dreissena* on the vertical distribution of oligochaetes at three long-term monitoring stations in the eastern basin of Lake Erie and compared our data with the results of previous studies. We found that the average oligochaete weight was significantly higher in samples with greater dreissenid density. Our results also suggested that higher densities of dreissenids may affect the vertical distribution of several species of oligochaetes (e.g. *Vejdovskyella intermedia*). *Keywords: Benthos, Dreissena, Monitoring.*

DANNER, K.M.[1], MAVE, M.A.[1], SAWYER, A.H.[1], and LEE, J.Y.[2], [1]School of Earth Sciences, The Ohio State University, 125 S Oval Mall, Columbus, OH, 43210, USA; [2]College of Public Health, The Ohio State University, 1841 Neil Avenue, Columbus, OH, 43210, USA. **Wave tank and numerical experiments to determine fate of microcystin in coastal sediment.**

Harmful algal blooms (HABs) have become more prevalent within Lake Erie in recent years. Microcystin is one of the most common and harmful toxins associated with HABs, but little is known about microcystin attenuation and fate in the environment. Our goal is to determine whether wave-driven benthic exchange may accelerate the attenuation of microcystin-LR (MC-LR) in shallow coastal waters. We are using laboratory wave tank experiments to quantify MC-LR mobility and attenuation in shallow sediments. Sediment was collected from Western Lake Erie and incorporated into a 110 gallon tank. A mixture of conservative chloride and MC-LR were simultaneously added to surface water under stagnant and wave conditions, and concentrations were monitored over time in surface water and shallow pore water. Surface water and pore water concentration data will be used to assess effective removal rates of MC-LR under stagnant and wave conditions. We are also developing two dimensional reactive transport models to assess the sensitivity of MC-LR removal rates to water depth, wave height, and sediment properties. Results can be used to assess the importance of lakebed sediments in attenuating MC-LR under various environmental conditions. *Keywords: Model studies, Microcystis, Sediments.*

DARWISH, T.[1], USVYATSOV, S.[1], and FIETSCH, C.L.[2], [1]Golder Associates Ltd., 6925 Century Avenue, Suite #100, Mississauga, ON, L5N 7K2, CANADA; [2]Bruce Power, 177 Tie Road, Tiverton, ON, N0G 2T0, CANADA. **A long-term Monitoring Study on Smallmouth Bass Nesting in the Bruce Power Discharge Channels.**

Fish inhabiting the waters of Lake Huron near the Bruce Power Nuclear Generating Station experience warmer water temperatures due to discharge of warmed cooling water. Historical use of the Bruce Power discharge channel by Smallmouth Bass (Micropterus dolomieu) for nesting was first documented in 1973 and bass remain in the discharge to this day. To understand the potential effects of elevated water temperatures on bass nesting success, Bruce Power commenced long term monitoring for bass spawning behaviour and reproductive success in 2009. Between 2009 and 2015, two discharge exposure areas and a reference area were surveyed during the bass spawning season. For each nest observed, the development of the nest, eggs, and fry were assessed. Environmental conditions were also recorded. Throughout monitoring, the number of bass using the discharge channels for nesting varied; however, nesting locations remained consistent. Analysis of data indicates that environmental variables play a larger role in nest development than site-specific thermal conditions associated with operations. Predictions made during environmental assessments of operational effects could not be disentangled from environmental variables. Future work could look at using the long-term dataset to establish a natural range of variability in nest numbers. *Keywords: Monitoring, Small mouth bass, Fish, Power generation channels.*

DAVENPORT, E.[1], TRINGE, S.[2], KRAUSFELDT, L.E.[3], DENNEY, M.K.[3], WILHELM, S.W.[3], MCKAY, R.M.[1], and BULLERJAHN, G.S.[1], [1]Bowling Green State University, Bowling Green, OH, USA; [2]DOE Joint Genome Institute, Walnut Creek, CA, USA; [3]University of Tennessee, Knoxville, TN, USA. **Diel Metatranscriptomics of the 2014 Lake Erie Microcystis Bloom.**

During the 2014 *Microcystis* bloom that directly affected the Toledo water supply, a Lagrangian survey was conducted in the western basin (Maumee Bay) over a 48-hour period (August 26-28th), collecting water samples every 6 hours. Examining metatranscriptomes derived from these samples allowed for partitioning of genes into those expressed during 'day' and 'night' time periods. Genes associated with night expression include those involved in chlorophyll and phycobilin biosynthesis, amino acid biosynthesis, and anaplerotic pathways. These highly expressed genes suggest pools of amino acids and pigments are predominantly synthesized at night. Currently, we are analyzing the day time period gene expression for functions associated with photosynthetic electron transfer, nutrient uptake and microcystin synthesis. *Keywords: Microcystis, HAB, Lake Erie, Genomics.*

DAVIS, J.J.[1], JACKSON, P.R.[2], ENGEL, F.L.[2], ZINGER, J.A.[2], NEELEY, R.N.[1], FINNEY, S.T.[3], and MURPHY, E.A.[2], [1]U.S. Fish and Wildlife Service, Carterville Fish and Wildlife Conservation Office, Wilmington SS, 30239 S. Route 53, Wilmington, IL, 60481, USA; [2]U.S. Geological Survey, Illinois Water Science Center, 405 N. Goodwin Avenue, Urbana, IL, 61801, USA; [3]U.S. Fish and Wildlife Service, Carterville Fish and Wildlife Conservation Office, 9052 Route 148, Marion, IL, 62959, USA. **Entrainment, retention, and transport of freely swimming fish in junction gaps between barges.**

Large electric dispersal barriers were constructed in the Chicago Sanitary and Ship Canal (CSSC) to prevent the transfer of invasive fish species between the Mississippi River Basin and the Great Lakes Basin while simultaneously allowing the passage of commercial barge traffic. We investigated the potential for entrainment, retention, and transport of freely swimming fish within large gaps (> 50 m3) created at junction points between barges. Modified mark and capture trials were employed to assess this potential pathway for upstream movement. A multi-beam sonar system enabled estimation of fish abundance within barge junction gaps. Barges were also instrumented with acoustic Doppler velocity meters to map the velocity distribution in the water surrounding the barge and in the gap formed at the junction of two barges. Observed transverse and vertical water velocities suggest pathways by which fish may potentially be entrained into barge junction gaps. Results of mark and capture trials suggested that small fish can become entrained by barges, retained within junction gaps, and transported over long distances (greater than 15 km). A proportion of the fish entrained within the barge junction gap were retained in that space as the barge tow transited through locks and the electric dispersal barriers. *Keywords: Acoustics, Fish management, Invasive species.*

DAVIS, T.W.[1], CORY, R.[2], SMITH, D.J.[2], MEYER, K.A.[2], WATSON, S.B.[3], BULLERJAHN, G.S.[4], GOSSIAUX, D.[1], MEISSNER, S.[5], and DICK, G.[2], [1]NOAA GLERL, Ann Arbor, MI, USA; [2]University of Michigan, Ann Arbor, MI, USA; [3]Environment and Climate Change Canada, Burlington, ON, CANADA; [4]Bowling Green State University, Bowling Green, OH, USA; [5]University of Potsdam, Potsdam, GERMANY. **Investigating the Role of Reactive Oxygen Species in Driving Bloom Toxicity in western Lake Erie.**

A growing body of evidence suggests that reactive oxygen species (ROS) may in fact be an important driver of cyanobacteria community structure and toxicity. ROS, such as hydrogen peroxide (H_2O_2), are highly toxic to cyanobacteria and other phytoplankton and have a profound effect on their physiology, but tolerance of ROS varies widely across taxa. Because ROS are produced through photochemical reactions with dissolved organic matter (DOM), there is a potential feedback between increasing DOM from blooms or terrestrial runoff, ROS, and cyanobacterial community composition and toxicity. Furthermore, a recent theory is that one ecological function of microcystins (MC) is to protect cells from oxidative stress. In this study, we monitored the concentrations of H_2O_2 and other water quality parameters across three sites in western Lake Erie weekly from June - October 2014. We coupled the monitoring with microcosm experiments investigating the effect of added H_2O_2 as a function of nutrient (N and P) concentrations on community composition, particulate, dissolved and conjugated MC and ratios of non-MC producing and MC-producing cyanobacteria. Our results suggest that ROS may play a role in bloom toxicity if nutrient concentrations are sufficient. *Keywords: Lake Erie, Microcystins, Harmful algal blooms, Microcystis.*

DAYTON, E.A. and WHITACRE, S.D., The Ohio State University, 2021 Coffey Rd., Columbus, OH, 43210, USA. **On-Field Ohio!: Evaluation/Revision of the Ohio Phosphorus Risk Index.**

The Ohio Phosphorus (P) Risk Index is intended to provide a field-scale estimate of P runoff risk. Increasingly it is being used to judge farmer performance. The objectives are to evaluate/revise the Ohio P Index to ensure it accurately reflects runoff P risk, is sufficiently protective of surface water quality, without un-necessarily harming agricultural production. Presented will be a project status overview. Ohio farmers have been asked for a 40% reduction in P loading into the Western Lake Erie Basin. A revised/improved Ohio P Index will provide information necessary to achieve reductions in offsite P transport.
Keywords: Nutrients, Agricultural runoff, Phosphorus.

DEAN, B.Y.[1], CORCORAN, P.L.[1], HELM, P.[2], and BALLENT, A.M.[1], [1]University of Western Ontario, 1151 Richmond Street, London, ON, N6A3K7, CANADA; [2]Ontario

Ministry of the Environment and Climate Change, Toronto, ON, CANADA. **Microplastics in beach and bottom sediments of Lake Erie and its tributaries.**

Lake Erie tributary, beach, and lake bottom sediments were sampled to determine the levels and types of microplastics pollution in one of the Laurentian Great Lakes. Tributary sediment was collected from four locations using a Petite Ponar grab sampler, 12 beach samples were collected using a Split Spoon Sampler, and 16 lake bottom samples were collected using a Shipek sediment grab sampler. All samples were density separated using a sodium polytungstate solution in order to isolate microplastics from sediment. Tributary samples contained 0-51 pieces of microplastic/100g of sediment, beach samples contained 0-71 pieces of microplastic/100g sediment, and lake bottom sediments contained 0-39 pieces of microplastic/100g of sediment. The compositions of the microplastics will be determined by Micro Raman Spectroscopy at the Smithsonian Institute. Quadrats were set up at six beaches over a period of one week in order to collect macroplastic accumulation data. The weekly accumulation of macroplastics in the quadrats ranged from 13-234 pieces. Plastics distribution maps of northern Lake Erie will indicate where future beach clean-up efforts and ecosystem investigations should focus. *Keywords: Microplastics, Great Lakes basin, Lake Erie.*

DEBERTIN, A.J. and NUDDS, T.D., University of Guelph, 50 Stone Road East, Guelph, ON, N1G 2W1, CANADA. **Social-ecological Dynamics and the Persistence of the Lake Erie Gillnet Fishery.**

Enigmatically, despite significant changes to the composition of species in the Lake Erie food web, fish harvesters continue to persist in their role as top predators, suggesting that the system is ecologically stable. Models of human behavior and fish population growth were used to determine whether foodweb dynamics might mitigate negative effects of harvest as conventionally considered. These models predicted that persistence of fisheries are characterized by asymmetries in prey preference by harvesters dictated by price or quota, but less so in competitive strength among harvested species. Predictions were empirically tested with long-term data on harvest, price and interaction strengths estimated from a suite of Bayesian stock assessment models of the four most harvested species, Walleye (*Sander vitreus*), Yellow Perch (*Perca flavescens*),White Perch (*Morone americana*) and White Bass (*Morone chrysops*). There was little evidence that fish species strongly competed. Furthermore, harvesters switched prey, between less-valued non-quota species, and more highly valued quota species, consistent with the expectation that prey switching is a stabilizing feature of food webs. This research demonstrates that mechanisms of persistence as decribed with foodweb theory could be used for multi-species management. *Keywords: Fish management, Walleye, Ecosystem modeling, Yellow, Lake Erie, Foodweb dynamics.*

DEBRUYNE, R.L.[1], ROSEMAN, E.F.[1], DUFOUR, M.R.[2], PRITT, J.J.[3], FISCHER, J.L.[2], and BENNION, D.H.[1], [1]USGS Great Lakes Science Center, Ann Arbor, USA; [2]University of Toledo, Lake Erie Center, Oregon, USA; [3]Ohio Department of Natural Resources, Columbus, USA. **Dynamics of Lake Whitefish Spawning and Larval Drift in the St. Clair-Detroit River System.**

Lake whitefish reproduction has been measured in the Detroit River using egg and larval surveys for the past 10 years and in the St. Clair River for the past 5 years. Egg deposition occurred at spawning sites throughout the Detroit River, but eggs were rare in the St. Clair River. Similarly, larval drift was much higher and occurred earlier in the Detroit River, while larval lake whitefish found in the St. Clair River were thought to be transients from Lake Huron. Channel-specific larval export from the lower Detroit River was estimated using a Bayesian approach. Export of larvae varied across years and channels, however the majority of lake whitefish larvae were exported through the highest volume channels including; Trenton, Livingstone, and Amherstburg. Total annual export of lake whitefish larvae ranged from 28.8 million in 2010 to 83.4 million in 2011 and was driven primarily by export from the Trenton and Amherstburg channels (~70%), those closest to the eastern and western riverbanks. Given the widespread spawning , large numbers of larvae produced, and continued restoration to water quality and aquatic habitat in the system, the Detroit River provides valuable habitat and added resilience to the lake whitefish population in Lake Erie and adjoining waters. *Keywords: Detroit River, Lake whitefish, Fish, Early life history, Lake Erie.*

DEPEW, D.[1], HIRIART-BAER, V.[1], KOEHLER, G.[2], and WASSENAAR, L.I.[2], [1]Environment and Climate Change Canada, 867 Lakeshore Rd, Burlington, ON, L7S 1A1, CANADA; [2]Environment and Climate Change Canada, 11 Innovation Blvd, Saskatoon, SK, CANADA. **Unravelling Phosphorus Dynamics in the nearshore of eastern Lake Erie.**

Fouling of shorelines in eastern Lake Erie by *Cladophora* has been a recurrent phenomenon since the mid 1990s. Recent efforts to develop load reduction targets have been hindered by uncertainties associated with the relative influences of external loads, P recycling by dreissenid mussels and exchange with offshore waters. The application of oxygen stable isotopes of phosphate offers a potentially novel and powerful method to distinguish different sources of bioavailable P and shed light on dominant cycling pathways. We measured $^{18}O-PO_4$ in water and biota in order to evaluate the utility of this method for identifying specific sources of P associated with blooms of *Cladophora* and improve our

understanding of dominant P cycling pathways in a highly complex near shore zone. Results indicate that bio-available P in the eastern basin is likely derived from hydrolysis of dissolved organic P compounds. Localized impact of the Grand River is also demonstrated and have a limited spatial extent. Implications for management of *Cladophora* in eastern Lake Erie will be discussed. *Keywords: Phosphorus, Eutrophication, Lake Erie.*

DERMINIO, D.S. and BOYER, G.L., State University of New York, College of Environmental Science and Forestry, 1 Forestry Dr., Syracuse, NY, 13201, USA. **Effects of Nutrient limitation on the Photosynthetic Efficiency of Microcystis Aeruginosa.**

Microcystis aeruginosa, a bloom-forming cyanobacterium, is responsible for many harmful algal blooms that occur in embayments of the Great Lakes. Recent work has suggested that nitrogen, in addition to phosphorus, may be important in controlling the growth of Microcystis in the western basin of Lake Erie. Traditional field experiments to determine how nutrient limitation affects Microcystis are often convoluted due to its slow growth rate and presence of other species. Nutrient-induced fluorescence transients (NIFTs) may provide a faster way to assess the nutrient status of cyanobacteria in natural settings in the presence of other species. NIFTs record the changes in the photosynthetic efficiency of species with the addition of variable nutrients. *Chlorella vulgaris* and *M. aeruginosa* LE3 were grown in N- and/or P-limited and replete (Z8 media) cultures that were spiked at different time with 0.06mM phosphate and 1.4mM nitrate. Their fluorescence response was measured using a PhytoPAM active fluorometer and Phyto-Win Software V 1.45 for 10 minutes pre- and post-addition of nutrients. Initial results suggest that changes in the fluorescent efficiency of cultures were dependent on both the species and availability of nutrients. The suitability of using NIFT's in capturing these changes will be investigated.
Keywords: Cyanobacteria, Fluorescence transients, Light.

DICKINSON, W.T. and RUDRA, R.P., University of Guelph, Guelph, ON, N1G 2W1, CANADA. **Ontario River Flows into the Great Lakes Have Changed as a Result of Climate Change & Urbanization.**

River flows across Ontario have changed over the last 100 years: winter flows have increased and spring flows have decreased in virtually all watersheds, and summer flows have significantly increased in highly urbanized watersheds - despite the fact that winter and summer precipitation amounts have not changed. The changes in flows therefore must be attributable to changes in other climatic variables and/or urban development. In this presentation, the increases in winter flows and decreases in spring flows are linked primarily to changes in winter climate; and the significant increases in both the volumes and frequencies of summer flows are attributed to urbanization. *Keywords: Urbanization, Streamflow, Climate change, Watersheds.*

DIFALCO, R.[1], CZAJKOWSKI, K.P.[2], and JOHANSEN, R.A.[2], [1]Michigan State University, 220 Trowbridge Rd, East Lansing, MI, 48824, USA; [2]University of Toledo, 2801 W. Bancroft, Toledo, OH, 43606, USA. **Agricultural Drainage Tile Density Compared to Natural Soil Drainage.**

The aim of this study was to map and predict subsurface tile density on agricultural fields to investigate phosphorous loading to the Western Basin of Lake Erie. Phosphorus as part of non-point source pollution may contribute to seasonal harmful algal blooms. This project examined the link between the density of agricultural tile and soil drainage. Agricultural fields across northwestern Ohio were surveyed to create a map that depicts agricultural tile density through a meters per acre index. Tile density has been linked to phosphorus loading; higher density results in more phosphorus runoff. This research produced a density map with 1800 fields of subsurface drainage systems across the Maumee Watershed, and in turn identified potential phosphorus hotspots. This map over lay, with a natural soil drainage, allowed a comparison between poorly drained soils and the amount of drainage systems in place. The majority of regions with very poorly drained soils also had the highest average tile per acre. A comparison between the crop types and amount of tile per acre yielded results of no difference between crop type and drainage density. This study's conclusion shows there is a link between poorly drained soils and degree of drainage tile while having a very even distribution across the study area. *Keywords: Phosphorous loading, Soil drainage, Field tile.*

DITTRICH, M.[1], MARKOVIC, S.[1], CADENA, S.[1], SWEETNAM, D.[2], and WATSON, S.B.[3], [1]University of Toronto Scarborough, 1265 Military Trail, Toronto, ON, M1C 1A4, CANADA; [2]Georgian Bay Forever, PO box 163, Caledon, ON, L7E5T2, CANADA; [3]Environment Canada, National Water Research Institute, 867 Lakeshore Rd, Burlington, ON, L7R4A6, CANADA. **Sediment geochemistry in South Eastern Georgian Bay: impact of land use on phosphorus loading.**

The interface of the Precambrian Shield and Paleozoic bedrock creates diverse and complex shorelines of the eastern coast of Georgian Bay. In the past several decades, development of residences, campgrounds, trailer parks and marinas significantly affected coastal ecosystems. Recently, oxygen depletion, high phosphorus concentrations and harmful algal blooms were observed in several deep Bays, including Honey Harbour, Twelve Mile Bay and Sturgeon Bay. Following a gradient in land use and occurrence of harmful algal blooms, we investigated several bays with the main focus on three sites in North and South

Bay and Honey Harbour. We investigated phosphorus flux from sediments and factors controlling its release. During one year, we measured redox, O_2, and pH profiles across sediment-water interface; analyzed dissolved phosphate and metals (Al, Fe, Mn, Si and Ca) content in pore waters; determined phosphorus binding forms using sequential extraction and analyzed metals associated with each phosphorus fraction. The total phosphorus content in surface sediments (<5cm) is 1.3-1.5 mg P/g dry weight, while the dominant binding forms are redox-sensitive and Al hydroxide bound phosphorus. The release of phosphorus from sediments varies between 0.4 and 3.5 mg P m2 d-1 with the highest values measured during late summer. *Keywords: Eutrophication, Phosphorus, Algal bloom, Georgian Bay.*

DOAN, P.[1], MARKOVIC, S.[1], CADENA, S.[1], GUO, J.[2], MCCLURE, C.[3], MUGALINGAM, S.[3], MORLEY, A.[4], and DITTRICH, M.[1], [1]University of Toronto Scarborough, 1265 Military Trail, Toronto, ON, M1C 1A4, CANADA; [2]Environment Canada, National Water Research Institute, 867 Lakeshore Rd, Burlington, ON, L7R 4A6, CANADA; [3]Lower Trent Conservation, 714 Murray Street, Trenton, ON, K8V 5P4, CANADA; [4]Minister of the Environment and Climate Change, Eastern Regions, 1259 Gardiners Road, Kingston, ON, K7M 8S5, CANADA. **Modelling of phosphorus internal loading in the Bay of Quinte, Canada.**

Excess phosphorus (P) inputs lead to harmful algal blooms (HABs). In turn, HABs and hypoxia have been linked to sediment P release, fueling more blooms and delaying response to management. Although there is considerable evidence that P release from sediments is controlled by P burial into deep sediments and redox conditions at the sediment surface, these processes are poorly characterized. In this study, we modeled P cycling in sediments of Bay of Quinte (BQ), using a long history of eutrophication. We applied a diagenetic model and a sediment core analysis to sites in three BQ basins (Belleville, Hay Bay, Napanee). In the model, P was divided into adsorbed, aluminium-bound, organic, redox-sensitive, and apatite forms. Moreover, using the fluxes of organic and inorganic matter as dynamic boundary conditions, the depth profiles of solid and dissolved substances were simulated. P releases, in addition to mass balances, were calculated and estimated; they related to geochemical conditions, and P binding forms in sediments. Our results showed that P release from BQ sediments is dominated by redox-sentive form of P and sediment accumulation can be a significant mechanism in moderating the levels of eutrophication in the Bay, especially at the Napanee station which exhibited the lowest P retention and greatest vulnerability to HABs. *Keywords: Bay of Quinte, Modeling, Sediments.*

DOMSKE, H.M., New York Sea Grant, Buffalo, NY, 14260, USA. **Great Lakes Sea Grant Network's Effective Aquatic Invasive Species Programming.**

Aquatic invasive species (AIS) have reduced biodiversity in water-based ecosystems through competition with native species for food and habitat. Organisms in Trade (OIT) pathways create a risk to spread new species through release or escape and spread established species to new ecosystems. The Great Lakes Sea Grant Network has developed successful education and outreach projects funded through the Great Lakes Restoration Initiative that are designed to educate teachers, students, anglers and other stakeholders about the impacts of OIT and AIS. Teachers who participated in these Sea Grant programs were introduced to new educational resources to teach students about how AIS and OIT relate to issues such as food webs, biodiversity, endangered species, climate change, and others. This presentation will provide an overview of these projects, as well as sharing some of the materials and products developed. *Keywords: Invasive species, Education, Outreach.*

DRAKE, D.A.R.[1], BAILEY, S.A.[2], and MANDRAK, N.E.[1], [1]Department of Biological Sciences, University of Toronto Scarborough, 1265 Military Trail, Toronto, ON, M1C1A4, CANADA; [2]Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries and Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7S 1A1, CANADA. **Demographic Parameters and Allee Effects Dictate Ballast-mediated Spread in the Great Lakes Basin.**

To understand the spread of invasive species across the domestic ballast network, we developed a spatiotemporally explicit model that joins a logistic growth function with demographic parameters describing the likelihood of species establishment. Allee effects were evaluated to determine their influence on spread, which we report as the time for receiving ports to become saturated with satellite populations. Rapid spread timelines occurred for species exhibiting extreme reproductive potential and lacking Allee effects, leading to establishment across 49.5% and 71.4% of sites at 5 and 20 years following their initial introduction. For species with relatively poor ability to invade, Allee effects increased the extent of spread during later years compared with an independence model (11.5% increase in number of established satellite populations at year 20 when $\alpha = 0.001$, $X0 = 5$). Our approach moves beyond the observational nature of many invasive species spread models, which can lead to overly confident management response. For highly invasive species, spread varied strongly based on the location of first introduction. Sites with low initial contribution provide a greater window within which management intervention can occur; however, failing to act quickly creates a strategic disadvantage that worsens as time proceeds. *Keywords: Invasive species, Risk assessment, Modeling.*

DROUILLARD, K.G. and GRIGORAKIS, S., Great Lakes Institute of Environmental Research, 2990 Riverside Drive W, Windsor, ON, N9C 1A2, CANADA. **Determining the gut retention coefficient of two types of plastic in goldfish.**

Microplastics are ubiquitous in aquatic environments and many organisms are exposed to them via ingested food. Microplastics have been identified in the gut tracts of fish from the Great Lakes and may contribute to possible health hazards related to intestinal blockage resulting in decreased feeding rates. Little is known about the dynamics of microplastic uptake and retention within the gastrointestinal tract of fish. This study characterized the gut retention of microplastics in goldfish following exposure to microbeads or microfibers added to commercial fish pellets. Either 50 microbeads or microfibers were incorporated into a pellet and fed to groups of fasted fish. Fish were then given ad libitum access to additional food over a period of 1h. Subsequently fish were fasted for up to 6 days with sacrifices completed after 1.5, 4, 8, 16, 32, 48, 96 and 144 h. Gut contents were removed from intestinal tract, dried, weighed to determine food retention, and then digested in 10%KOH for microplastic analysis. The t90 of digesta in the gi-tract ranged from 93.6 to 159h across treatments. Microplastic retention was shorter than digesta with t90 values of 101.4 and 93.6h for microbead and microfibers. Results indicate that both microplastic types are readily flushed from the gut and not retained beyond normal digesta retention.
Keywords: Microplastics, Bioaccumulation, Fish.

DRURY, C.F., REYNOLDS, W.D., YANG, X.M., and YANG, J.Y., Agriculture & Agri-Food Canada, Harrow, ON, N0R1G0, CANADA. **Managing Reactive Nitrogen in the Great Lakes Basin.**

The impact of agriculture on soil, water and air quality in sensitive areas of national and international importance (e.g. Great Lakes Basin) requires new strategies to reduce nutrient losses from fertilizers and manures. Nitrogen fertilizer sales have more than doubled from the 1980's to the present and urea based fertilizers (urea and UAN) now account for 74% of the Canadian N fertilizer sources. From 1981 to 2011, ammonia volatilization from fertilizers have doubled and nitrous oxide emissions have increased by 37%. Nitrate leaching through tile drains into ditches streams and lakes has also increased by 2.8 fold. Field trials involving various N sources, inhibitors and application methods have been conducted using wind tunnels, static chambers and soil core samples. These studies have identified the extent of these N losses to the environment and best management practices have been developed for the soils and climate in the Great Lakes Basin. In particular we have found that injecting N fertilizer with urease inhibitors can reduce ammonia volatilization by 97%, the combined use of urease and nitrification inhibitors can

reduce nitrous oxide emissions by over 20% and the reduction of environmental losses has resulted in increased crop yields and profitability. *Keywords: Nutrients, Nitrogen, Water quality, Ammonia, Indicators, Nitrate.*

DUFOUR, M.R.[1], MAYER, C.M.[1], QIAN, S.S.[1], VANDERGOOT, C.S.[2], KRAUS, R.T.[3], KOCOVSKY, P.M.[3], and WARNER, D.M.[4], [1]University of Toledo, 2801 W. Bancroft St., Toledo, OH, 43606, USA; [2]ODNR-DOW Sandusky Fisheries Research Station, 305 E. Shoreline Dr., Sandusky, OH, 44870, USA; [3]USGS Lake Erie Biological Station, 6100 Columbus Ave., Sandusky, OH, 44870, USA; [4]USGS Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105, USA. **Hydroacoustic abundance estimates and Walleye (*Sander vitreus*) avoidance behavior: a tale of two ships.**

Lake Erie walleye (Sander vitreus) occupy relatively shallow water and are a large, mobile target; therefore, acoustic abundance estimates may be influenced by avoidance behavior. We performed an inter-ship comparison survey to determine the effect of ship size, diel period, environmental conditions, and depth on abundance estimates. We collected hydroacoustic data with BioSonics DTX split-beam systems and 200 kHz transducers using a 0.2 msec pulse duration and 10 pings per second. Ships traversed 4 8-km parallel transects during the day and repeated transects on adjacent nights. We surveyed a shallow site (Sandusky sub-basin; 10-15 m) during fall 2013 and a deep site (Central basin; 15-20 m) during summer 2015. We echo-counted large targets > -33.5 dB (i.e., > 400 mm) for survey cells defined by 1000 m distance intervals and 5 m depth layers. We compared cell densities using a Bayesian Poison ANOVA. Walleye appeared to use horizontal avoidance behavior and greater densities were observed with smaller ships, during the night, in more turbid waters, while the avoidance effect decrease with depth. Results also indicated that researchers should prioritized capturing small-scale spatial variation, the greatest source of uncertainty, during future survey development. *Keywords: Acoustics, Walleye, Lake Erie.*

DUHAIME, M.B., CABLE, R., BELETSKY, D., and BELETSKY, R., University of Michigan, Ann Arbor, USA. **Microbial Trash Surfers: Modeling Transit and the Ecology of the Great Lakes Plastic Microbiome.**

While the accumulation of plastic debris in nature is one of the most pervasive environmental concerns of our time, too little is known about the fate of this plastic and its role in ecosystem dynamics to predict the inevitable impacts on one fifth of the world's fresh water and valuable national security asset, the Great Lakes. In an analysis of microbial communities from hundreds of pieces of plastic debris and water samples from across three Great Lakes--in combination with insights from hydrodynamic particle transit models--we present a model for plastic biofilm microbial community assembly and discuss implications

for environmental and public health. These data highlight the incredible diversity of microbes that plastic debris harbors and the potential for urban centers and infrastructure (e.g., high population density, WWTP effluent) to serve as a source for this diversity.
Keywords: Microplastics, Microbial, Modeling.

DUHAIME, M.B., BERRY, M., SCHNUR, A., DEVLIN, P., and DICK, G., University of Michigan, Ann Arbor, USA. **Lake Erie Viruses: 'Viromic' Approaches to Track the Killers of Erie's Blooming Microbes.**

We seek to better understand the role of viruses in shaping the ecological and evolutionary trajectory of Lake Erie's annual harmful algal bloom (HAB) events. To date, only three viruses infecting *Microcystis aeruginosa*--the primary agent of HABs in Erie's western basin--have been described, yet existing data intimate viruses to be key community players in the etiology and progression of Erie HABs. For instance, evidence suggests that viruses influence the toxicity of the dominant bloom strains in nature. Further, sequenced *Microcystis* representatives have among the highest incidence of CRISPR/CAS systems (a microbial system of acquired immunity) of all sequenced microbes, suggesting active defenses against virus attack are common in this host. Despite encouraging evidence of Lake Erie virus-induced death in our *Microcystis* cultures, our attempts at isolating *Microcystis* viruses from Lake Erie have been woefully unsuccessful. Thus, in this study we turn to community 'omics approaches to describe the diversity and function of viral communities through the 2014 Erie bloom. We explore the utility of this data type in linking virus with host to identify and track *Microcystis aeruginosa* viruses *in silico* thereby informing our understanding of these virus-host interactions in nature. *Keywords: Virus, Microbe, Genomics.*

DULAL-WHITEWAY, C.J. and TRICK, C.G., University of Western Ontario, 1151 Richmond Street, London, ON, N6A 5B7, CANADA. **Fish-killing Activities of Prymnesium parvum.**

Prymnesium parvum is a harmful algal bloom species (HABs). It can inhabit a broad range of salinities, which has allowed it to make the ecological leap from marine to freshwater. *Prymnesium* blooms have been responsible for mass fish kills, disrupting native populations and devastating fisheries. Suboptimal growth conditions play a large role in influencing the toxicity of *Prymnesium* cells. However, this role is not well understood. One form of toxicity displayed by *Prymnesium* is the lysis of red blood cells (hemolytic activity), to scavenge nitrogen and iron from blood. The measurement of hemolytic activity is directly correlated to the overall toxicity of *Prymnesium*. Hemolytic activity was observed to be dependent on the *Prymnesium* isolate and cell density. Higher hemolytic activity was observed

in lysed *Prymnesium* cells than intact cells. Light, temperature, salinity, macro- and micro-nutrients were found to impact hemolytic activity. Conditions that resulted in a lower growth rate also resulted in lower hemolytic activity. *Prymnesium* has recently spread to freshwater systems throughout the United States and is expanding its range north. This makes it a pertinent HABs to study because it is a potentially invasive species in the Great Lakes. *Keywords: Invasive species, Toxic substances, Phytoplankton.*

E

EATON, L.A., WARNER, D.M., ARMENIO, P.M., EPPEHIMER, D.E., and BUNNELL, D.B., USGS-Great Lakes Science Center, Ann Arbor, MI, 48105, USA. **An exploration of spatiotemporal variation in the Lake Michigan *Mysis diluviana* population.**

The native macroinvertebrate *Mysis diluviana* is an integral component of the Great Lakes food web, linking the benthic and pelagic food webs and serving as an energy-rich prey resource for fish. *Mysis* undergo diel vertical migration and are influenced by forces throughout the water column. We used a unique seasonal data set from Lake Michigan that quantifies both abiotic (i.e., temperature, depth) and biotic (e.g., prey availability, predator density) characteristics to identify drivers of variation in *Mysis* populations (e.g., density, mean size, sex ratios, fecundity) throughout Lake Michigan in 2015. Because previous research has shown that *Mysis* size tends to be smaller at nearshore sites, we hypothesize that top-down forcing (i.e., predation) drives nearshore *Mysis* populations whereas bottom-up forcing (i.e., food availability) drives offshore *Mysis* populations. Samples were collected from eight sites in Lake Michigan in the spring, summer, and fall of 2015 at nearshore to offshore sites (18m, 46m, 110m). We will determine whether variation in *Mysis* characteristics can be best explained by depth, temperature, chlorophyll *a*, or fish abundances. Biomass of preferred zooplankton prey will also be available from a subset of the data to include in explanatory models. *Keywords: Lake Michigan, Macroinvertebrates, Nutrients.*

ECKERT, W., Israel Oceanographic and Limnological Research, The yigal Allon Kinneret Limnological Laboratory, Migdal, ISRAEL. **Longterm Changes in P-Cycling of a Subtropical Lake due to Man-Made Perturbations and Climate Change.**

Our study on the phosphorous (P) cycle of Lake Kinneret presents an overview of more than 40 years of research and monitoring while following up earlier published assessments on P-partitioning, sedimentation and diagenesis. The P evolution in the water column is described based on understanding of physical forcing processes and their role in internal P-loading. Our results point towards a novel transport mechanism that is responsible for the depletion of SRP in the hypolimnion. A whole-lake mass balance model, based on data from the 1970s, is updated according to the annual P-fluxes measured later-on while taking into consideration previously neglected components such as aeolian P inputs. Our long-term trends indicate dramatic changes in the TP-inventory. Between the early eighties and the early 2000s the TP content of Lake Kinneret dropped by 30%. The observed drop is linked to man-made perturbations in the watershed that led to a gradual reduction of allochthonous inputs and internal P-loads. The relationship between the observed changes in P loading rates and changes observed in the Lake Kinneret ecosystem is discussed. *Keywords: Phosphorus, Watersheds, Climate change.*

ECKMAN, K.[1], TEASLEY, R.L.[2], KOWALCZAK, C.[3], NEWMAN, D.[4], GURUNG, T.[1], and SMITH, H.[2], [1]University of Minnesota, Minneapolis, MN, USA; [2]University of Minnesota Duluth, Duluth, MN, USA; [3]Fond du Lac Tribal & Community College, Cloquet, MN, USA; [4]Minnesota Extension, Cloquet, MN, USA. **Factors Contributing To Community Resilience in Extreme Climatic Conditions.**

This project explores factors contributing to resiliency demonstrated by two communities impacted by flooding in the St. Louis River Basin. The region experienced an extreme annual exceedance probability for worst case 24-hour rainfall in 2012. The flood caused more than $100 million in road and infrastructure damage in fifteen counties and the Fond du Lac tribal nation. We focus on two communities in a region likely to experience future extreme storms due to climatic variability: the Fond du Lac tribal community of Ojibwe; and Fond du Lac village, a small town located southwest of Duluth. Both communities exhibited strong internal social bonds, mutual assistance and informal communication. This spontaneous local resilience and community bonding, despite the challenges of isolation caused by infrastructure failure, is highlighted. Our goals include three areas: community resilience, communication and civil engineering. Widespread damage to engineering lifelines such as dams, roads and bridges took place. While the two communities experienced unprecedented disaster, property loss and dislocation, strong underlying community bonds and actions contributed to resiliency and recovery. We use a mixed methods approach combining engineering and social science research methods (e.g. field surveys; oral histories; and KAP study). *Keywords: Lake Superior, Outreach, Climate change.*

EDDINS, D.J., SNYDER, M.R., MARSHALL, N.T., and STEPIEN, C.A., University of Toledo Lake Erie Center, 6200 Bayshore Rd., Toledo, OH, 43616, USA. **Population Genetics of Invasive Eurasian Ruffe over Time and Space.**

In ~1986 Eurasian ruffe (*Gymnocephalus cernua*; family Percidae) invasions were discerned in St. Louis Harbor, Lake Superior and Bassenthwaite Lake, northern England. The former originated from ballast water (with genetic origins from the Baltic Sea region) and the latter from bait bucket transfers from southern England. Our study aims to: (1) compare differentiation and diversity patterns of invasive versus native populations, and (2) analyze whether genetic compositions have changed over time, using 10 nuclear DNA microsatellite loci. Results indicate: (1) both invasions were large introductions from different sources, with just slight founder effects, (2) they have pronounced differentiation, with the native Baltic Sea and Great Lakes populations being similar, (3) their genetic compositions have remained consistent over time (early 1990s-present), and (4) there is great genetic similarity across the Great Lakes distribution, indicating range expansion of the initial colonists, without additional introductions. This study shows that population genetic analyses provide robust and informative information for discerning the spatial and temporal patterns of invasions. *Keywords: Fish populations, Ruffe, Genetics, Gymnocephalus, Invasive species.*

EDGAR, R.[1], MORRIS, P.[1], ROZMARYNOWYCZ, M.J.[1], D'SOUZA, N.[1], MONIRUZZAMAN, M.[3], BULLERJAHN, G.S.[1], WILHELM, S.W.[3], BOURBONNIERE, R.[2], and MCKAY, R.M.[1], [1]Bowling Green State University, Bowling Green, OH, 43403, USA; [2]Environment Canada, Burlington, ON, CANADA; [3]The University of Tennessee, Knoxville, TN, USA. **Metatranscriptome Analysis of Lake Erie's Winter Diatom Bloom.**

Here we describe a metatranscriptome constructed from an ice-associated phytoplankton community in Lake Erie dominated by filamentous diatoms. As expected, a high percentage (69%) of the sequences with BLAST hits to nucleotides or proteins in NCBI databases were associated with photosynthetic algae of which the majority were *Aulacoseira* spp. and *Stephanodiscus* spp. which was confirmed by analysis of 18S rRNA gene transcripts and microscopy. Consistent with the winter growth environment, psychrophilic- and low-light adaptations were observed. Prominent among adaptations to cold were transcripts for genes involved in biosynthesis of unsaturated fatty acids required for membrane fluidity. Reflecting the low light environment of the ice-covered Lake were an abundant complement of reads for light-harvesting antennae, mainly genes encoding fucoxanthin chlorophyll a/c proteins. The presence of virulence factors originating from oomycetes offers support for new hypotheses into the eventual decline of Lake Erie's winter diatom bloom. Whereas parasitic chytrids were identified, dsRNA viruses of fungi were detected that may indirectly defend against chytrid infection. This study demonstrates the utility of an environmental 'omics approach to yield insights underlying phototrophic life in an extreme environment. *Keywords: Diatoms, Ice, Lake Erie.*

EDGE, T.A.[1] and MACKLIN, J.[2], [1]Environment and Climate Change Canada, 867 Lakeshore Road, Burlington, ON, L7R 1A1, CANADA; [2]Agriculture and Agri-Food Canada, Ottawa, ON, CANADA. **EcoBiomics: New Federal Genomics Research Project.**

Through the Genomics Research and Development Initiative (GRDI), federal science based departments and agencies collaborate in the field of genomics research to address biological issues that are important to Canadians. In April 2016, the GRDI will be launching an interdepartmental collaborative project, EcoBiomics, to take advantage of synergistic advances in next generation sequencing and high performance computing which are opening the door to more widespread and cost-effective applications of metabarcoding (i.e. taxonomic diversity), metagenomics (i.e. taxonomic and functional gene diversity), and metatranscriptomics (i.e. diversity of expressed genes) technologies. The EcoBiomics project will focus on application of these techniques to better understand the extent and significance of ongoing changes to biodiversity in the soil and aquatic ecosystems that sustain essential ecosystem services upon which Canadians and our economy depend. An overview will be provided of the EcoBiomics project, its focus at the interface of soil and aquatic ecosystems, and a summary of projects, including those working on Lake Erie, Ontario and Lake Champlain, Quebec. *Keywords: Genetics, Biodiversity, Genetics.*

EIMERS, M.C. and WATMOUGH, S.A., Trent School of the Environment, Trent University, 1600 West Bank Drive, Peterborough, ON, K9L 0G2, CANADA. **Changes in Total Phosphorus and Nitrate Concentrations in Lake Ontario tributaries.**

Total phosphorus (TP) concentrations have declined over the past four decades at many southern Ontario streams, whereas nitrate (NO_3-N) concentrations have increased, leading to shifts in N:P ratios. Similar changes have been observed in Lake Ontario, which suggests that watershed export is an important driver of changes in Lake Ontario nutrient levels. We evaluated seasonal patterns in TP and NO_3-N concentrations across 15 major tributaries that vary in land cover from almost entirely urban to predominantly agricultural, in an attempt to identify possible causal factors. Trends were relatively consistent across seasons, and there were surprisingly few trends in nutrient concentrations at the two most urbanized watersheds. In contrast, changes in stream nutrient concentrations were most dramatic in the least populated, most agricultural watersheds. While the total footprint of agricultural land may have declined slightly in these watersheds, the type of agricultural practices (i.e. landuse) occurring in Ontario (and beyond) have undergone more dramatic changes over recent decades. We suggest that changes in agricultural land use practices over the past forty years, including shifts in crop type, tile drainage and tillage practices may be contributing to stream nutrient patterns. *Keywords: Nutrients, Tributaries, Watersheds.*

EL-ANSARI, O. and TRICK, C.G., Department of Biology, Western University, 1151 Richmond Street, London, ON, N6A 5B7, CANADA. **Ecophysiology and toxin production of the benthic freshwater cyanobacterium *Lyngbya wollei*.**

Cyanobacterial blooms pose a significant global problem and threaten the health of the ecosystem due to their ability to produce noxious and toxic compounds that are known to be harmful to humans. The devastating effects of algal blooms have induced high mortality in aquatic organisms such as fish resulting in severe economic losses. Filamentous benthic cyanobacteria of the species *Lyngbya wollei* are commonly found in southeastern United States and have recently been reported in the Laurentian Great Lakes. *L. wollei* strains from southeastern United States and Australia have been shown to produce saxitoxins and hepatotoxins respectively. The toxins produced by the filamentous cyanobacterium from the Laurentian Great Lakes are not well known and will be investigated. The objective of this research is to examine the conditions promoting the production, concentration and type of toxins produced by filamentous cyanobacteria from the Great Lakes. The influence of seven environmental factors such as temperature, light intensity, pH, nitrogen, phosphorus, iron, calcium will be tested on *L. wollei* dry weight and toxicity. Understanding the physiological responses of *L. wollei* to different environmental stresses will allow us to mitigate effectively the harmful effects of *L. wollei* toxic blooms. *Keywords: Harmful algal blooms, Benthos, Invasive species.*

ELBAGOURY, D.[1], ZHAO, J.[2], YERUBANDI, R.[2], SMITH, R.E.H.[3], HIRIART-BAER, V.[2], ACKERMAN, J.D.[4], and BOEGMAN, L.[1], [1]Queen's University, Kingston, ON, CANADA; [2]Environment Canada, Burlington, ON, CANADA; [3]University of Waterloo, Waterloo, ON, CANADA; [4]University of Guelph, Guelph, ON, CANADA. **Identifying and Assessing the Impacts of Phosphorus Loads in Eastern Nottawasaga Bay.**

The phosphorus (P) fractions and algae species in eastern Nottawasaga Bay, Lake Huron, and its tributaries are being investigated to develop an understanding of nutrient status, sources of phosphorus, and consequences for algal dynamics and other water quality outcomes. From 1973 to 1982, the phosphorus concentrations in Nottawasaga Bay averaged 4-6 μg/l; however, phytoplankton densities at stations near urban centres and river inflows were significantly higher than at more remote offshore sites and attest to the use of phytoplankton as a sensitive measure of trophic status in Georgian Bay. The P and algae data will be applied to simulate the fate and transport of algae blooms within the Nottawasaga River plume using the computational model ELCOM-CAEDYM. The model will be applied to improve environmental monitoring, assess the scientific information required to measure the effectiveness of control strategies, and identify and approaches to reducing P discharges. Here, we report on validation of the hydrodynamic model ELCOM and present preliminary biogeochemical simulations from CAEDYM. *Keywords: Phosphorus, Nottawasaga Bay, Algae, Water quality.*

ELLIOTT, C.W.[1], HOLDEN, J.P.[2], CONNERTON, M.J.[3], and TUFTS, B.L.[1], [1]Department of Biology, Queen's University, 116 Barrie St., Kingston, ON, K7L 3N6, CANADA; [2]Ontario Ministry of Natural Resources and Forestry, Lake Ontario Management Unit, 41 Hatchery Lane, Picton, ON, K0K 3E0, CANADA; [3]NYSDEC, Lake Ontario Fisheries Research Unit, 541 East Broadway, Cape Vincent, NY, 13618, USA. **The Use of Mobile Hydroacoustic Surveys to Assess Predator Species Abundance in Lake Ontario.**

Currently open-lake assessments of salmonids in Lake Ontario are only conducted through fishery-dependent surveys. Mobile hydroacoustic surveys of Lake Ontario began in 1992 to assess Alewife (*Alosa pseudoharengus*) and Rainbow Smelt (*Osmerus mordax*) abundance through a joint survey conducted by the Ontario Ministry of Natural Resources and Forestry and the New York State Department of Environmental Conservation. The purpose of this study was to determine if these surveys could also be used to index predator abundance and make inferences about specific salmonid species, primarily Chinook Salmon (*Oncorhynchus tshawytscha*), Lake Trout (*Salvelinus namaycush*) and Rainbow Trout (*Oncorhynchus mykiss*). Non-metric multidimensional scaling (NMDS) was used to group large hydroacoustic targets based on various parameters such as water depth, height in the water column, distance offshore and target strength. This grouping may then be used to inform species specific partitioning of large targets and their abundance. This study may provide fisheries managers with new insights regarding open-lake predator abundances and distributions allowing more informed decisions regarding stocking and harvest regulations. *Keywords: Acoustics, Predation, Lake Ontario.*

EMBKE, H.S.[1], KOCOVSKY, P.M.[2], RICHTER, C.A.[3], GARCIA, T.[4], MAYER, C.M.[1], and QIAN, S.S.[1], [1]University of Toledo, Lake Erie Center, Department of Environmental Sciences, 6200 Bayshore Road, Oregon, OH, 43618, USA; [2]U.S. Geological Survey, Great Lakes Science Center, Lake Erie Biological Station, 6100 Columbus Avenue, Sandusky, OH, 44857, USA; [3]U.S. Geological Survey, Columbia Environmental Research Center, 4200 New Haven Road, Columbia, MO, 65201, USA; [4]U.S. Geological Survey, Illinois Water Science

Center, 405 N Goodwin Ave, Urbana, IL, 61801, USA. **Assessing Spawning Locations of Naturally Spawned Grass Carp Eggs in a Great Lakes Tributary.**

Invasive grass carp (*Ctenopharyngodon idella*) have been stocked for decades in the United States for vegetation control. Adults have been found in all of the Great Lakes except Lake Superior, but no self-sustaining populations have yet been identified in Great Lakes tributaries. Previous research suggested natural reproduction has occurred in the Sandusky River; hence we sampled ichthyoplankton using paired bongo net tows June through August 2015 to determine if grass carp are spawning. We identified and staged eight eggs that were morphologically consistent with grass carp. Five eggs were confirmed as grass carp using quantitative PCR, while three were retained for future analysis. All eggs were collected during high flow events, either on the day of or 1-2 days following peak flow, supporting a suggestion that high flow conditions favor grass carp spawning. From our findings, we used hydrologic modeling to calculate the most likely spawning locations for these eggs. Preliminary model results suggest eggs were most likely released near the hypothesized spawning site in Fremont, Ohio. These locations will help guide future sampling efforts, inform risk assessments and aid targeted control efforts. *Keywords: Fish, Invasive species, Modeling.*

EPPEHIMER, D.E.[1], WARNER, D.W.[1], ARMENIO, P.M.[1], EATON, L.A.[1], NOWICKI, C.J.[1], BUNNELL, D.B.[1], RUTHERFORD, E.S.[2], and WELLS, D.J.[3], [1]USGS Great Lakes Science Center, 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. **Lake Michigan Larval Fish Densities and Growth Rates across a Nutrient Gradient.**

Changing ecosystem dynamics in Lake Michigan due to the dreissenid mussel invasion have contributed to declines in nutrient availability, reduced primary production, and altered zooplankton community composition. Whether or not these bottom-up effects are contributing to long-term declines in forage fish densities remains unclear. One possible mechanism is that this altered food-web is reducing the growth and survival of larval fishes. In July 2015, as a part of the Cooperative Science and Monitoring Initiative, larval fish were sampled at nine nearshore-to-offshore transects throughout Lake Michigan. Transects were positioned with varying distance to tributaries with different phosphorous loads. Larval fish were collected at night using surface and oblique tows with 500 micron ichthyoplankton nets and were subsequently identified and measured. Otoliths were extracted from a subset of alewife and bloater to determine age and growth rate. We hypothesize that transects closer to tributaries with high phosphorus loads will have higher larval fish densities and faster growth rates, owing to greater prey resources. Preliminary results indicate the highest densities of larval fish were found at the St. Joseph transect, which is adjacent to the highest phosphorous-loading tributary (i.e. St. Joseph River). *Keywords: Lake Michigan, Larval Fish, Phosphorus, Tributaries.*

ERDLE, L.[1] and BALLENT, A.M.[2], [1]Ontario Streams, 50 Bloomington Rd W., Aurora, ON, L4G 0L8, CANADA; [2]University of Western Ontario, 109 Western Science Centre, London, ON, N6A 5B7, CANADA. **Education Opportunities in Microplastics for Youth.**

The issue of plastic pollution challenges communities around the Great Lakes, and is an especially large threat around major urban centres. Many communities are taking action to deal with plastic pollution through local clean-up efforts and in the Greater Toronto Area students have begun investigating microplastics in Lake Ontario. In a local initiative run by community volunteers, students collected and analyzed surface samples from Humber Bay, Ashbridges Bay and Toronto Harbour using a citizen science framework that also encourages community action. The goal is to effectively communicate the types and sources of microplastics and subsequent impacts of plastic pollution. To achieve this goal, sampling events led by community volunteers and high school students aboard a Toronto tallship and school workshops have been developed. The workshops provide hands-on educational experiences in the field and in the classroom as well as research results which may be used to monitor the microplastics levels in the region. We discuss, in particular, experiences of working with school groups, and how involvement in this science can encourage microplastics awareness and generate new ideas in developing solutions for the burgeoning plastics problem. *Keywords: Microplastics, Education, Lake Ontario.*

ERLER, A.R.[1], D'ORGEVILLE, M.[2], and PELTIER, W.R.[2], [1]Aquanty Inc., Waterloo, CANADA; [2]University of Toronto, Toronto, CANADA. **Climate Change Impacts in the Great Lakes Basin based on High-resolution Regional Climate Projection.**

Within the Laurentian Great Lakes Basin (GLB), climate change influences on weather patterns and the hydrologic cycle may impart significant influence on the regional economy. However, confidence in climate projections derived from global climate models (GCMs) is relatively low in this region because of inconsistencies across models and also because the lakes themselves are poorly represented in GCMs. Here we present an ensemble of dynamically downscaled regional climate projections at 10 km resolution for the GLB that are derived from a suite of lower resolution GCM simulations. The regional climate model employed for this work is the state-of-the-art WRF model (V3.4) which was coupled to an interactive lake model (FLake). Results show that this approach towards modeling the regional GLB climate can reproduce historical conditions with a reasonable degree of accuracy while also capturing the influence of the lakes on the regional climate at a level not usually attained. Based on our future climate projections, we will discuss potential longer term (i.e. 2050 and 2100) climate change impacts, including changes to the hydrologic cycle in watersheds within the GLB, with particular emphasis on changes in precipitation extremes and other hydro-climatic extremes such as floods and droughts. *Keywords: Climate change, Hydrologic cycle, Model studies.*

ESHENRODER, R.L. and MUIR, A.M., Great Lakes Fishery Commission, 2100 Commonwealth Blvd., Ann Arbor, MI, 48105, USA. **Source Populations for Reintroduction of *Coregonus artedi*.**

Based on unpublished morphological data and a literature review undertaken in the production of a monograph on the ciscoes of the Great Lakes, we propose that there are two types of Coregonus artedi that may be used as sources for reintroduction. One type is representative of the wide-ranging populations that formerly dominated Lakes Michigan, Huron, and Ontario, was relatively rare in in Lake Erie, and remains widespread in Lakes Superior. This type, fusiform in shape, was known as the blueback or typical artedi, except in Lake Erie where a deep-bodied form was dominant, although this deep-bodied type, named albus, is no longer observable in the residual population. The albus type is associated now with irregular shorelines such as bays in Lakes Michigan and Huron. Extant albus diverge considerably in morphology from the typical artedi that once dominated Lakes Michigan and Huron, whereas in Lake Erie typical artedi and albus had been much-more similar morphologically. Even though indirect evidence indicates that both phenotypes owe to plasticity in C. artedi, caution should be used in selecting a brood source as the ability to express alternative phenotypes may have been under selection, resulting in important differences among populations with consequences for reestablishment. *Keywords: Fish behavior, Coregonus artedi, Fish management, Fish populations.*

EUCLIDE, P.T.[1], PARENT, T.[1], GONZALEZ, E.[2], FLORES, N.[3], WARGO, M.J.[1], KILPATRICK, C.W.[1], and MARSDEN, J.E.[1], [1]University of Vermont, Burlington, VT, 05401, USA; [2]Universidad del Turabo, Guarabo, PR, USA; [3]California State University of Sacramento, Sacramento, CA, USA. **Effect of Fish Dispersal Ability on Sensitivity to Habitat Fragmentation in a Large Lake.**

Habitat fragmentation negatively impacts natural processes, leading to reduced genetic diversity and conservation concerns. Since the mid 1800s, construction of ten major causeways in Lake Champlain has progressively divided the lake into relatively isolated basins, providing a novel opportunity to study the consequences of whole-lake fragmentation on population restructuring of fishes. We used this causeway fragmentation to test how barriers affect the genetic connectivity of fish species with different dispersal abilities. We sampled three coldwater fish species with different dispersal behavior: slimy sculpin (low dispersal), lake whitefish (medium dispersal), and rainbow smelt (high dispersal) from three basins of Lake Champlain separated by causeways. We used molecular genetic techniques and Bayesian population mapping to identify population structure of each species and calculated genetic distance among basins for each species. Our results are consistent with species-specific effects of causeways on gene flow. Lake whitefish form three distinct populations in basins separated by causeways, whereas preliminary analysis of slimy sculpin and rainbow smelt genetic distances suggests little to no isolation among basins. Results suggest that causeways may be an incomplete barrier to some fish species. *Keywords: Genetics, Habitat fragmentation, Fish, Fish behavior.*

EVANS, D.O.[1], MAZUMDER, A.[2], MAZUMDER, S.[2], KOPF, V.E.[1], and GINN, B.K.[3], [1]Ontario Ministry of Natural Resources and Forestry, 2140 East Bank Drive, Peterborough, ON, K9J 7B8, CANADA; [2]University of Victoria, 3800 Finnerty Road, Victoria, BC, V8W 3N5, CANADA; [3]Lake Simcoe Region Conservation Authority, 120 Bayview Parkway, Newmarket, ON, L3Y 3W3, CANADA. **Stable isotopes and plant pigments in sediment cores map changes in trophic state over two centuries.**

Our objective is to map changes in nutrient enrichment, aquatic primary production and trophic state of Lake Simcoe from predevelopment to present day. Sediment cores were collected through ice cover during February, analyzed for stable isotopes (d^{13}C and d^{15}N), 15 fossil plant pigments and dated using ^{210}Pb activity. Time plots of d^{13}C and d^{15}N in the sediment cores revealed clear temporal break points in aquatic production and trophic state. Bi-plots of d^{13}C and d^{15}N indicated five distinctive trophic phases in the development of the watershed: pre-European settlement and pre-disturbance baseline (1700-1800); early settlement and land clearance (1800-1900) with increasing anthropogenic N inputs; early to mid 20th century development (1900-1960) with a sharp increase in anthropogenic N inputs and elevated productivity; recent rapid changes associated with urbanization (1960-1993); and post-dreissenid invasion (1996-present). Sedimentary chlorophyll a, representing all higher plants and algae, plotted versus d^{15}/N more clearly revealed historical shifts in primary production and trophic state, and also revealed differences in sediment deposition between the lake basins. *Keywords: Lake Simcoe, Plant pigments, Paleolimnology, Trophic state, Stable isotopes.*

EVANS, L.J., NOWELL, P., VICKERS, S., and ZHANG, X., University of Guelph, Guelph, ON, N1G2W1, CANADA. **Predicting Phosphate Retention in Agricultural Soils using a Soil Adsorption/Precipitation Computer.**

Management of agricultural cropping systems is an important strategy to mitigate the export of non-point source phosphate and hence reduce phosphorus loading to the Great Lakes. Understanding the chemistry of soil phosphate in the agricultural landscapes of southern Ontario is essential for on-farm decision-making. A computer model was written in Visual Basic using the algorithms in MICROQL to predict the retention of applied phosphate in a number of southern Ontario agricultural soils. The surface characteristic of clay and oxide minerals were investigated by potentiometric titrations and phosphate binding constants to clay and oxide minerals by batch adsorption experiments at varying pH. Using the Constant Capacitance Model, data from the potentiomentric titrations and the batch adsorption experiments were optimized by the software program FITEQL. The resulting determined proton and phosphate binding constants for both clay and oxide minerals were then incorporated into a soil adsorption/precipitation model. The model considers aqueous phosphate speciation, precipitation of secondary phosphate minerals and phosphate adsorption to soil clay mineral assemblages and oxide minerals. *Keywords: Phosphorus, Biogeochemistry, Environmental health.*

EVERHARDUS, E.[1] and BOND, K.[2], [1]Ontario Ministry of the Environment & Climate Change, 135 St. Clair Avenue West, 6th Floor, Toronto, ON, M4V 1P5, CANADA; [2]Ontario Ministry of Education, Mowat Block, 900 Bay Street, 4th Floor, Toronto, ON, M7A 1L2, CANADA. **Building Durable Great Lakes Education Partnerships.**

Ontario's Ministry of the Environment and Climate Change and Ministry of Education have brokered innovative partnerships to support partners' efforts to bring Great Lakes into the classroom. Focussed on building literacy and capacity of Ontario's Grades 11-12 teachers, the Ministries' have piloted hands-on learning teacher and student conferences on a Great Lakes shoreline, bringing together school boards and conservation authorities (CA's) whose boundaries overlap. Partners have benefited by: 1) school board representatives and teachers discovering the wealth of skills, knowledge and facilities that CA's have locally to fulfill their watershed management mandate; and 2) CA's are beginning to adjust their educational programming to align with their school boards priority-funded programs, to better serve all students' needs (i.e., university-, college-, apprenticeship-, and workplace-bound learning streams). The Great Lakes Education Model has drawn the attention of science, geography, and other teachers from across the Great Lakes & St. Lawrence River Basin, home to 98% of Ontarians. The model has proven successful with its interdisciplinary and experiential focus, helping teachers use the Great Lakes as a tool to

connect their students to authentic learning opportunities related to real world challenges.
Keywords: Great Lakes basin, Education.

F

FAKOURI BAYGI, S., CRIMMINS, B.S., HOPKE, P.K., and HOLSEN, T.M., Clarkson University, 8 Clarkson Avenue, Potsdam, NY, 13699, USA. **Comprehensive Emerging Chemical Discovery: Polyfluorinated Compounds in Lake Michigan Trout.**

A screening algorithm using the bioinformatics toolbox of MATLAB has been developed to search liquid chromatographic/mass spectrometric data for novel environmental contaminants. The algorithm attempts to detect isotope profile and possible fragmentation pathways of candidate contaminants. The algorithm has been validated using known perfluorinated compounds. A compound matrix consisting of 3570 possible candidate contaminants including C_4-C_{10} of perfluoro- and polyfluoroalkyl, polyfluorochloroalkyl acids and sulfonates, and potential ether forms plus their chlorinated forms were investigated. Applying this approach to Lake Michigan trout extracts revealed the presence 30 compounds. Eight groups of polyfluorinated compounds were identified, including mono-fluoroalkyl carboxylic acids, tri-fluoroalkyl carboxylic acids, tetra-fluoroalkyl carboxylic acids, penta-fluorodecanoic acid, hexa-fluorodecanoic acid, mono-fluoroalkyl ether carboxylic acids, tri-fluoroalkyl ether carboxylic acids and polyfluoroalkyl sulfonate. In some cases, intensity of the identified compounds is 25% of the intensity of perfluorooctane sulfonic acid suggesting a significant loading of these compounds the Great Lakes trout.
Keywords: Data acquisition, Perfluorinated compounds, Environmental contaminants, High resolution mass spectrometry, Lake Michigan, Unknown identification.

FARHA, S.F.[1], BINDER, T.R.[2], JANSSEN, J.[3], RILEY, S.C.[4], MARSDEN, J.E.[5], HANSEN, M.J.[2], BRONTE, C.R.[6], and KRUEGER, C.C.[1], [1]Center for Systems Integration and Sustainability, Michigan State University, Lansing, MI, USA; [2]Hammond Bay Biological Station, Great Lakes Science Center, USGS, Millersburg, MI, USA; [3]School of Freshwater Science, University of Wisconsin-Milwaukee, Milwaukee, WI, USA; [4]Great Lakes Science Center, USGS, Ann Arbor, MI, USA; [5]Rubenstein School of Environment and Natural Resources, University of Vermont, Burlington, VT, USA; [6]Green Bay National Wildlife and Fish Conservation Office, US Fish and Wildlife Service, New Franken, WI, USA. **Lake Trout Spawning Habitat Selection in the Drummond Island Refuge: Paradigm or Paradox?**

The recovery of Great Lakes lake trout has been slow, potentially reflecting an inability of hatchery-reared lake trout to select habitats suitable for successful incubation. We

addressed this hypothesis using a novel acoustic telemetry-based approach to apportion sampling effort based on behavior of tagged fish. In 2013-14, 70 sites varying by habitat use were physically characterized, surveyed for egg deposition and evaluated for incubation success using an in situ habitat bioassay. Egg deposition was confirmed at 21 sites and logistic regression/AIC were used to quantitatively rank the importance of physical characteristics to predicting the presence of eggs. Initial analyses indicated that substrates selected for egg deposition were more uniform, smaller in diameter, had deeper interstitial depth, and greater bathymetric slope than sites not selected. Additionally, sites selected for egg deposition had the highest incubation success, suggesting lake trout were capable of finding suitable spawning habitat within the Refuge. Nonetheless, lake trout spawned on a variety of substrates, including several that were inconsistent with the lake trout spawning habitat paradigm. Interestingly, these sites also produced viable fry, forcing us to rethink, adapt, and expand our conceptual understanding of suitable trout spawning habitat.
Keywords: AIC, Recruitment, Spawning Habitat, Lake trout, Fish behavior.

FARROW, C.R.[1], SNIDER, D.M.[2], YERUBANDI, R.[2], DEPEW, D.[2], HIRIART-BAER, V.[2], and ACKERMAN, J.D.[1], [1]University of Guelph, Guelph, ON, CANADA; [2]Environment Canada, Burlington, ON, CANADA. **Effects of Riverine Inputs on Phytoplankton Community Structure.**

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 (usually genera) using custom statistical filters in water samples from six cruises from late July through October 2015. The concentration of cells (or colonies in the case of colonial taxa) was found to differ among sampling sites and dates. For example, Gyrosigma had its highest particle concentrations in July and Early August, especially in the river mouth site. Conversely, small-celled mucilaginous Cyanobacteria (resembling Microcystis, Aphanocapsa, or Aphanothece) had their highest particle concentrations in the Fall (September-late October) at sites located outside the river mouth. These data should provide insight into how river loading affects primary production. *Keywords: Eutrophication, Phytoplankton, Species composition.*

FAUSTO, E., Ontario Climate Consortium Secretariat, Vaughan, ON, CANADA. **State of Climate Change Science in the Great Lakes Basin.**

Climate change is perhaps the greatest environmental challenge facing the ecosystem health of the Great Lakes Basin. Experts have called for both an improved understanding of ecological vulnerability and a more strategic approach to achieving climate resilience. Given the importance of scientific knowledge and information as an input to adaptive management, a shared understanding of the state of the science, including current strengths, gaps and levels of confidence, is critical to identifying research priorities and to co-operatively identify and respond to climate change impacts across the Great Lakes Basin. Recently, a report led and published by the Ontario Climate Consortium in partnership with MNRF, McMaster University and Environment Canada provides a firm foundation for future work in the Great Lakes Basin, by identifying knowledge strengths, weaknesses, gaps, priorities and opportunities. It recognizes that the Great Lakes Basin consists of the aquatic ecosystems of the five Great Lakes themselves, as well as the watersheds that influence Basin-wide health. The report's primary focus is on ecosystems; however, connections to economic activities and social well-being that are directly tied to the health of ecosystems are also considered, such as agriculture, nature-based tourism and human health. *Keywords: Climate change, Great Lakes basin, Ecosystems.*

FEINER, Z.S.[1], SWIHART, R.K.[1], COULTER, D.P.[1], and HÖÖK, T.O.[2], [1]Department of Forestry and Natural Resources, Purdue University, West Lafayette, IN, 47907, USA; [2]Department of Forestry and Natural Resources, Illinois-Indiana Sea Grant, Purdue University, West Lafayette, IN, 47907, USA. **Importance of fatty acid complexity to reproductive fitness in yellow perch (*Perca flavescens*).**

Trophic ecology often distills complex multivariate data, e.g., diets and fatty acids, into single metrics or coarse categories, overlooking within- and among-individual variation in the diversity of different components and overall phenotypic complexity of organisms. However, increasing complexity in, for example, fatty acid composition may contribute as much to individual fitness as the abundance of a few common compounds. We used a novel statistical method to quantify fatty acid complexity in the egg and somatic tissues of female yellow perch (*Perca flavescens*) exposed to three overwinter thermal regimes (4, 8, and 13°C), to evaluate i) how overwinter temperature regulates complexity in fatty acid composition, and ii) how fatty acid complexity contributes to female maturation and egg quality. Initial results indicate that fatty acid composition was consistent within treatments, but that fish held in warm treatments expressed potentially simpler phenotypes than fish held in cold temperatures. Recognizing total phenotypic complexity of important trophic and biochemical indicators could lead to novel insights into the responses of individuals and populations to environmental change. Such a perspective could be incorporated into large lake studies considering variation across complex, multivariate phenotypic traits.
Keywords: Environmental effects, Fatty acids, Fish, Percids.

FELIPE MARTINEZ, B.[1] and IMELDA GALERA, C.[2], [1]De La Salle University Dasmarinas, dasmarinas Philippines, Ca, 4114, USA; [2]De La Salle University Dasmarinas, Cavite Philippines, USA. **Monitoring and Evaluation of Water Quality of Taal Lake, Taal Batangas Philippines.**

The study is an update on the physico-chemical properties of Taal Lake for local and government officials and non-government organizations. A total of nine (9) water quality parameters were monitored and analyzed. The study shows that Taal Lake's surface temperature, pH, total dissolved solids, total suspended solids, color, and dissolved oxygen content conform to the standards set by the DENR while phosphate, chlorine,and 5-Day 20°C BOD are below the standard. T-test result shows that there is no significant difference in the overall average of the two sites at Taal Lake ($P > 0.05$). Based on the data, the lake is safe for primary contact recreation such as bathing,swimming, and skin diving and can be used for aqua culture purposes.

FERA, S.A.[1], BANNISTER, A.E.[2], DRAKE, D.A.R.[3], HUNT, L.M.[2], and JOHNSON, T.B.[1], [1]Ontario Ministry of Natural Resources and Forestry, 41 Hatchery Lane, Picton, ON, K0K 2T0, CANADA; [2]Ontario Ministry of Natural Resources and Forestry, Thunder Bay, ON, CANADA; [3]University of Toronto Scarborough, Toronto, ON, CANADA. **Predicting establishment and spread of invasive species in the Great Lakes under climate change.**

Changing climate conditions are likely to impact the dispersal and establishment of aquatic invasive species in the Great Lakes. We performed a risk assessment of species of concern by matching species habitat requirements with the Intergovernmental Panel on Climate Change (IPCC)'s Fifth Assessment Report (AR5) climate models over the next century. The suitable temperatures for survival, reproduction and growth of fish were identified and compared to statistically downscaled temperature projections under three representative concentration pathways from the AR5 (2.6, 4.5, and 8.5). The likelihood of species spread was evaluated for key fish species that are already established in the Great Lakes basin, as well as a list of potential invaders compiled from the literature. This temperature-matching model allowed us to create a list of the most likely invaders in each scenario, and to identify which parts of the Great Lakes basin and the province of Ontario are most at risk of hosting new species. These predicted futures allow adaptive management practices to be developed under multiple possible climate change scenarios. *Keywords: Invasive species, Climate change, Modeling.*

FERNANDO, S., CRIMMINS, B.S., HOLSEN, T.M., and HOPKE, P.K., Center for Air Resources Engineering and Science, Clarkson University, Box 5708, 8 Clarkson Avenue,

Potsdam, NY, 13699, USA. **Evaluation of Emerging Contaminants in Great Lakes Fish using GCxGC-HRT.**

The Great Lakes Fish Monitoring and Surveillance Program (GLFMSP) has traced the fate and transport of anthropogenic chemicals in the Great Lakes for decades. The contemporary impact of emerging contaminants was recently recognized and the program has dedicated significant resources to understanding the threat posed by non-legacy toxic chemicals. The identification of novel contaminants in top predator fish is a major challenge due to the complex biological matrix. Traditional legacy chemical purification steps can potentially discriminate against unknown toxic chemicals present in the original extracts. To enhance the comprehensive screening ability of GLFMSP, top predator fish extracts have been analyzed using a state-of-the-art two-dimensional gas chromatograph coupled to a High Resolution Time of flight mass spectrometer (GCxGC-HRT-MS, LECO). Due to the increased peak capacity and mass accuracy offered by GCxGC, and HRT, respectively, fish tissue extracts were injected with minimal sample cleanup. Identifications were performed by library spectral matching and molecular formula estimations using high resolution data. The efficacy of this technique as a targeted screening/confirmation and non-targeted discovery tool will be assessed with a summary of novel chemicals observed in Great Lakes top predator fish. *Keywords: Environmental contaminants, GC/HRMS, Lake trout.*

FISCHER, J.L.[1], ROSEMAN, E.F.[2], KENNEDY, G.W.[2], CRAIG, J.[2], MANNY, B.A.[2], BENNION, D.H.[2], and MAYER, C.M.[1], [1]University of Toledo, Department of Environmental Sciences, Toledo, OH, USA; [2]USGS Great Lakes Science Center, Ann Arbor, MI, USA. **Getting Physical: Guiding Habitat Restoration with Velocity and Substrate Mapping.**

Identifying priority areas for habitat restoration requires accurate physical measurements. For river restoration projects, water velocity is often a critical variable that is difficult to measure at the required spatial scale. Acoustic Doppler current profilers (ADCP) allow spatially and depth referenced water velocity to be continuously measured along a cross-section. Making ADCP measurements along many closely spaced cross-sections, allows water velocities to be mapped and flow patterns assessed. ADCP surveys were used to guide projects restoring coarse spawning substrates for native fishes in the St. Clair-Detroit River System (SCDRS) by identifying areas where substrates would remain free of fine sediments, which could fill interstitial spaces required for egg deposition and incubation. Surveys of previously completed projects indicated areas where water velocity increased in the downstream direction tended to remain free of fine sediments. Additionally, side-scan sonar was used to map substrate and verify sediment movement patterns indicated by ADCP surveys. Flows measured by ADCP surveys and confirmation of substrate conditions by side-scan sonar helped guide recent spawning reef installations and provided a basis for future reef restoration within the SCDRS and other connecting channels of the Laurentian Great Lakes. *Keywords: St. Clair River, Restoration, Acoustics, Habitat, Detroit River.*

FITZPATRICK, F.A., RENEAU, P.C., BREITMUN, M.G., and DANTOIN, E.D., U.S. Geological Survey, 8505 Research Way, Middleton, WI, 53562, USA. **Baseline Mining-Related Geochemical Assessment of Water and Sediment in the Bad River Mouth.**

In 2014-15, the U.S. Geological Survey (USGS) conducted a baseline geochemical assessment of water and sediment from the Bad River mouth and its plume area at Lake Superior, Wisconsin. The goal of the study was to describe baseline geochemical patterns that might be affected by potential taconite mining in the upper Bad River watershed. Sampling in the rivermouth and plume area in Lake Superior was coordinated with ongoing efforts in upstream areas of the Bad River and its tributaries through cooperative monitoring with the Bad River Tribe and the USGS Great Lakes Restoration Initiative Tributary Monitoring Program. Water sampling for trace elements in 2014-15 was conducted using USGS low-level ultra-clean techniques. Bed sediment was collected for trace elements from the lake plume area in the summer of 2015. Water-quality sonde and acoustic velocity data were collected along transects in the vicinity of the sampling to further describe plume/lake-water mixing. In this presentation we will describe how sampling efforts for water and sediment in the rivermouth and plume areas were integrated with sampling design, sample preparation, and laboratory analyses from ongoing and previous studies in the Bad River watershed, and with other mining-related studies in the Lake Superior Basin. *Keywords: Water quality, Tributaries, Lake Superior.*

FITZPATRICK, M., MUNAWAR, M., NIBLOCK, H., and ROZON, R., Fisheries & Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7S 1A1, CANADA. **Microbial Food Web Dynamics in the Deep Chlorophyll Maxima: Lake Ontario and Beyond.**

Deep Chlorophyll Maxima (DCMs) are a transient characteristic of large oligotrophic lakes (as well as oceans) that are widely assumed to provide an important food resource for higher trophic levels. This paper will consider the validity of that assumption by exploring the contribution of phytoplankton and microbial communities to the organic carbon pool both within the DCM and relative to other strata in the water column. This will include examples from Lake Ontario as well other parts of the Great Lakes. In Lake Ontario during the mid-summer, we found that the size of the organic pool ranged from 0.3 g C/m3 in the epilimnion to 0.1 g C/m3 in the hypolimnion compared to 0.2 g C/m3 at the DCM. Smaller picoplankton typically had the highest carbon turnover rates except for the epilimnion, where larger net plankton were more active. Our findings suggest considerable variability in the structure and function of the microbial food web throughout the water column and indicate that the contribution of the DCM as a vector for energy transfer may not be unique when compared to the other strata. *Keywords: Carbon, Heterotrophs, Phytoplankton, Photosynthesis.*

FLECK, S.J., PÉREZ-FUENTETAJA, A., CLAPSADL, M.D., and SNYDER, R.J., SUNY Buffalo State, 1300 Elmwood Ave, Buffalo, NY, 14222, USA. **Habitat use of larval fish in the macrophyte beds of Niagara River wetlands.**

Over the last century, the Great Lakes region has experienced large changes in historic species assemblages and interactions. A disproportional negative effect may be evident in fish that require particular types of littoral nursery habitats during early life stages. Macrophyte beds composed of different aquatic plant assemblages provide cover from visual predators and sustenance for various species of fish larvae in littoral zones. Understanding the relationship between macrophyte form and function and the larval fish that utilize them can help inform ecological theory and restoration efforts. In late summer 2015, biweekly samples of larval fish and macrophytes were collected from three wetland sites along the Niagara River. The first two sites had macrophyte beds primarily composed of *Vallisneria americana* and *Stuckenia pectinata*, accompanied by the less common *Myriophyllum sp.* and *Ceratophyllum demersum*. The third site was more diverse, principally composed of *Chara sp.*, *Najas spp.*, *Potamogeton spp.*, and *Nymphaea odorata*. The first two sites supported relatively fewer number of fish compared to the third, more diverse site. *Keywords: Fish populations, Vegetation, Niagara River, Macrophyes, Wetlands.*

FLOOD, B.[1], WELLS, M.G.[1], YOUNG, J.[2], and DUNLOP, E.S.[3], [1]University of Toronto Scarborough, Toronto, ON, CANADA; [2]Ontario Ministry of the Environment and Climate Change, Toronto, ON, CANADA; [3]Ontario Ministry of Natural Resources, Peterborough, ON, CANADA. **Estimation of flushing rates driven by large amplitude internal waves in a coastal embayment.**

Kempenfelt Bay contains the majority of Lake Simcoe's coldwater fish habitat. Motivated by recent improvements in water quality and natural recruitment, investigations were undertaken in 2015 to characterize the bay's water circulation, in particular the flushing rate between the bay and the main basin. We show that large internal waves act as "bellows" and flush water into and out of the bay. We observed Internal waves with amplitudes in excess of 15 m, or approximately ½ of the maximum depth. These waves potentially flush up to half of the embayment's water each period (~ 70 h). With average velocities of approximately 4 cm/s, water parcels near the shore potentially move back and forth by 5 km each period, resulting in a significant amount of exchange between Kempenfelt Bay and the main basin of Lake Simcoe. Internal Kelvin waves decay exponentially away from the shore, concentrating the largest amplitudes and velocities in the near shore zone, resulting in complex, non-linear flushing dynamics. During the stratified period of 2015 (July - Sept), 8 thermistor chains and 2 ADCP were deployed to record internal wave and water current dynamics within the bay. The data collected from this campaign are used to estimate the flushing rate of Kempenfelt Bay. *Keywords: Water currents, Lake Simcoe.*

FOLEY, C.J.[1], BOWEN, G.[2], HENEBRY, M.L.[1], CZESNY, S.J.[3], JANSSEN, J.[4], BOOTSMA, H.A.[4], and HÖÖK, T.O.[1], [1]Purdue University Department of Forestry and Natural Resources, 195 Marsteller Street, West Lafayette, IN, 47907, USA; [2]University of Utah Department of Geology & Geophysics, 115 South 1460 East, Salt Lake City, UT, 84112, USA; [3]Illinois Natural History Survey, 400 17th Street, Zion, IL, 60099, USA; [4]University of Wisconsin-Milwaukee School of Freshwater Science, Milwaukee, WI, USA. **Importance of terrestrial inputs to small-bodied, nearshore fishes in Lake Michigan.**

Population numbers of small-bodied fishes in nearshore Lake Michigan vary spatially and temporally, presumably in response to local, regional, and seasonal changes in habitat and feeding. While some studies have described what these fishes consume, relatively few have examined the contribution of different nutrient sources to fish diets. The potential for terrestrial inputs to the nearshore zone varies with spatial location and time of year (e.g., water is diverted away from the lake in the southwest; rivers and drowned river mouths provide pulses of nutrients to nearshore regions of the east). We used hydrogen (δ^2H) and oxygen (δ^{18}O) stable isotope ratios to understand the relative importance of terrestrial inputs to the diets of round goby and yellow perch populations in Lake Michigan. We examined fishes caught at a maximum depth of 15m, collected over three seasons and two years from sites with variable substrates. Hydrogen and oxygen stable isotopes are a relatively novel tracer used in food web studies of freshwater systems, and we compare our results to those obtained by more established techniques, namely gut content, fatty acid, and carbon (δ^{13}C) and nitrogen (δ^{15}N) stable isotope analyses. *Keywords: Stable isotopes, Lake Michigan, Fish.*

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. **Assessing the Utility of Landsat 8 for Monitoring Cyanobacteria in the Great Lakes Region.**

Cyanobacteria blooms have been increasing throughout the Great Lakes and surrounding regions. In 2015, Lake Erie reported a record setting bloom and the New York State Department of Environmental Conservation reported blooms in five of the Finger

Lakes. Monitoring blooms in smaller water bodies and the near shore waters of the Great Lakes using imaging satellites with coarse spatial resolution (e.g. MODIS) is difficult. Landsat 8 has better potential in this task due to its 30 meter spatial resolution, coastal spectral band, and improved radiometric resolution and signal-to-noise ratio. We tested the ability of Landsat 8 to monitor blooms through retrieval of phycocyanin and chlorophyll-a concentration. Retrieval was accomplished using a model based look-up-table technique. We determined accuracy of retrieval from real imagery and simulated data generated with the Hydrolight modeling software. We also simulated a spectral band near the 620 nm phycocyanin absorption feature to determine if additional bands on future Landsat missions could improve performance. These results indicate potential for bloom monitoring in smaller inland waters using Landsat. *Keywords: Remote sensing, Landsat, Cyanophyta, Harmful algal blooms.*

FRANCY, D.S.[1], STELZER, E.A.[1], STRUFFOLINO, P.S.[2], BARNSWELL, K.D.[2], and DWYER, D.F.[2], [1]US Geological Survey, Ohio Water Science Center, 6480 Doubletree Avenue, Columbus, OH, 43229, USA; [2]University of Toledo, Lake Erie Center, 6200 Bayshore Road, Oregon, OH, 43616, USA. **Developing Models for Predicting Microcystin Concentrations at Ohio Recreational Lakes.**

Cyanobacterial harmful algal blooms (cHABs) and associated toxins, such as microcystin, are a major global water-quality issue. cHAB prediction is complicated and site-specific because of the many factors affecting toxin production. Samples were collected at three Ohio recreational lakes to identify factors that could be used to develop two types of models to predict microcystin concentrations: (1) real-time models that include continuously-measured factors and environmental data, and (2) comprehensive models that use results from samples analyzed and real-time factors. For real-time models, significant correlations between microcystin concentrations and factors included phycocyanin, turbidity, pH, streamflow from a nearby river, lake-level change over 24 h, and Secchi depth. For comprehensive models, significant correlations were found for several nutrient constituents, cyanobacterial genes, and cyanobacterial biovolume or abundance. Relations between these factors and microcystin concentrations were site-specific and differed at the same site depending on whether data were continuously or discretely measured. Models with high R2 values, high sensitivities, and high specificities were developed at one of the study sites for predicting microcystin concentrations above/below the Ohio Recreational Public Health Advisory. *Keywords: Harmful algal blooms, Modeling, Decision making.*

FRASER, G.E., MARKLE, C.E., CAMPBELL, S.D., and CHOW-FRASER, P., McMaster University, 1280 Main Street W, Hamilton, ON, L8S 4K1, CANADA. **Long-term habitat changes before and after extirpation of the spotted turtle (*Clemmys guttata*).**

Point Pelee National Park, located on the north shore of Lake Erie, is an important refuge of rare Canadian herpetofauna. Unfortunately, habitat fragmentation, invasive species and human development have caused the disappearance of at least five amphibian species, five reptile species and one turtle species, the spotted turtle (*Clemmys guttata*). Point Pelee was once a stronghold for this species, presumably because of the plentiful sandy beach and dunes that provided turtle nesting sites. A contributing factor to their extirpation may be loss of this nesting habitat as well as decreased connectivity between wetlands and beaches. We will use aerial imagery dating from 1931 to present-day to track long-term changes in available habitat along the beach and major wetlands. Patterns in habitat change before and after its extirpation in 1991 will provide insight to what may have contributed to its disappearance. Since this endangered species is found only in small, isolated populations in Ontario, our project will reveal the importance of critical habitat to support this species, and aid development of habitat-specific protection plans for remaining populations in the province. *Keywords: GIS, Reptiles, Coastal wetlands.*

FREY, S.K.[1], LAPEN, D.R.[2], PARK, Y.J.[1], HWANG, H.T.[1], EDWARDS, M.[2], GOTTSCHALL, N.[2], and HUSSAIN, S.I.[2], [1]Aquanty, 564 Weber St N., Waterloo, ON, N2L 5C6, CANADA; [2]Agriculture and Agri-Food Canada, 960 Carling Ave, Ottawa, ON, K1A0C6, CANADA. **Tile drainage management influences on nutrient movement following swine manure applications.**

Tile drainage management is considered a beneficial management practice for reducing nutrient loads in surface water. Previous research has shown that controlling tile discharge via control structures with adjustable stop gates can be very effective for reducing tile discharge volume, and that on an annualized basis there is often a reduction in nitrate loads that is proportional to the reduction in discharge. In this presentation we will discuss results from field and modeling experiments designed to assess the influence of drainage management on nutrient and rhodamine tracer movement following liquid swine manure application on clay loam soil. Results from the modeling coincide with the field experiments by demonstrating that over a 36 day period following manure application, tile discharge was higher and more continuous, and peak rhodamine concentrations were lower in effluent from the freely drained plots; as compared to controlled drainage, where discharge was intermittent and peak rhodamine concentrations were higher. Scenario analysis revealed that in conditions where slight upwards hydraulic gradients exist in tile drained settings, groundwater upwelling can dilute the concentration of surface derived solutes under free

draining conditions; whereas controlled drainage can act to reduce groundwater movement into tiles. *Keywords: Environmental contaminants, Agriculture, Model studies, Beneficial management practices, Nutrients, Tile drainage.*

FRIES, K.J.[1], KERKEZ, B.[1], GRONEWOLD, A.D.[2], SPENCE, C.[5], BLANKEN, P.D.[4], LENTERS, J.D.[3], and CUTRELL, G.J.[3], [1]University of Michigan, Ann Arbor, MI, 48109, USA; [2]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, 48108, USA; [3]LimnoTech, Ann Arbor, MI, 48108, USA; [4]University of Colorado, Boulder, CO, 80309, USA; [5]Environment Canada, Saskatoon, SK, CANADA. **Improving Spatiotemporal Estimates of the Great Lakes Surface Energy Balance.**

Significant uncertainty exists in our understanding of over-lake hydrometeorological dynamics. This is particularly true of those variables that drive evaporation, which - until recently - has been one of the least quantified components of the Great Lakes water balance. This knowledge gap is amplified during the winter and early spring when in situ observations from buoys are non-existent. However, an untapped source of data is provided by the Volunteer Observing Ships program, which aggregates sensor measurements from dozens ships that traverse the lakes on a daily basis. By probabilistically assimilating these measurements into current operational models, we derive updated and spatiotemporally dense estimates of air temperature, wind speed, dew point, and surface water temperature. These data are used to create maps of the Bowen Ratio and are validated through comparison with point-based flux tower measurements at two locations, showing good agreement during months with significant sensible and latent heat flux. This new data product is analyzed to estimate spatiotemporal trends of evaporation. The use of these data in more complex energy balance and bulk transfer models is discussed, and the predictive uncertainty is used to provide recommendations for future placement of stationary observing platforms. *Keywords: Air-water interfaces, Observing systems, Spatial distribution.*

FRY, L.[1], SEGLENIEKS, F.[2], GRONEWOLD, A.D.[3], FORTIN, V.[4], and NOEL, J.[5], [1]U.S. Army Corps of Engineers Detroit District Great Lakes Hydraulics and Hydrology Office, Detroit, USA; [2]Environment Canada Boundary Waters Issues Unit, Burlington, CANADA; [3]National Oceanic and Atmospheric Administration Great Lakes Environmental Research Laboratory, Ann Arbor, USA; [4]Environment Canada Meteorological Research Division, Dorval, CANADA; [5]National Oceanic and Atmospheric Administration Ohio River Forecast Center, Willmington, USA. **Advances in binational coordination of overlake precipitation data for Great Lakes water management.**

Sustainable water management in the Great Lakes requires monitoring and communication of changes in the water budget, which is complicated by the need for binational hydrologic data from multiple sources with varying degrees of bias and uncertainty. Since 1953, the Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data has provided binational standardization of data required to monitor and manage the water budget of the Great Lakes. Until recently, a limited number of data sources existed for Great Lakes hydrologic data, which led to a relatively simple coordination process. While the datasets that were produced through this process were a significant contribution to Great Lakes water budget monitoring and management, more recent advancements in measurement and modeling have resulted in the availability of multiple data sources. The coordination process is now under revision to allow for inclusion of multiple, and sometimes conflicting data sources to ultimately achieve a better representation of the true historical values of water budget variables. We will present a methodology for gathering, evaluating, and aggregating Great Lakes hydrologic data to produce communicable coordinated products that reflect long term and recent changes in water budget components, focusing on precipitation as an example. *Keywords: Great Lakes basin, Data coordination, Hydrologic budget.*

FUTIA, M.H. and RINCHARD, J., The College at Brockport - State University of New York, Brockport, NY, 14420, USA. **Evaluation of egg thiamine concentrations in Lake Ontario salmonids.**

For several decades, thiamine deficiency has been impacting salmonid populations in the Great Lakes region leading to early mortality syndrome (EMS). Offspring with EMS show abnormal behaviors and encounter high mortality between the hatching and first feeding stages. As a result, successful recruitment of offspring in feral populations has been limited. In the present study, we evaluated the prevalence of thiamine deficiency in eggs of brown trout, steelhead trout, chinook salmon, and coho salmon collected from Lake Ontario and surrounding tributaries (Sandy Creek: Hamlin, NY and Salmon River: Altmar/Pulaski, NY) during their spawning migration. Egg thiamine was quantified using a high-performance liquid chromatography system. Subsamples of eggs from individual females were also fertilized and embryo survivals were followed until the first feeding stage. We will present the results of this study and the potential impacts of EMS on these species.
Keywords: Vitamin B, Early mortality syndrome, Salmon, Lake Ontario.

G

GAO, D. and ACKERMAN, J.D., University of Guelph, 50 Stone Rd. East, Guelph, ON, N1G 2W1, CANADA. **The Effects of Collector Motion on Particle Capture.**

Particle capture is important for many aquatic processes including submarine pollination, suspension feeding and larvae settlement. The standard model for examining particle capture is a stationary cylindrical collector but it does not account for the natural movements of collectors in nature that occur due to fluid-structure interactions. The effects of collector oscillation (amplitude and frequency of movement; transverse and longitudinal to oncoming flow) on particle capture efficiency was examined in a flow chamber. Results from the experiments indicated collector oscillation could lead to increased particle capture and varying distribution patterns, especially at low collector Reynolds number (Re_c). The increase was largest for collectors moving transverse to oncoming flow and moving with large magnitudes (i.e. 50-935% increase) likely because the collector encountered more particles with higher relative momentum. These results can be used to predict the effect of organism motion on particle capture and help focus new research by providing capture expectations. *Keywords: Hydrodynamics, Particle capture, Suspension feeding.*

GATCH, A.J.[1], RAZAVI, N.R.[1], CLECKNER, L.B.[1], HALFMAN, J.D.[2], CUSHMAN, S.F.[2], FOUST, J.C.[3], and GILMAN, B.I.[3], [1]Finger Lakes Institute, 601 South Main Street, Geneva, NY, 14456, USA; [2]Hobart and William Smith College, 300 Pulteney Street, Geneva, NY, 14456, USA; [3]Finger Lakes Community College, Canandaigua, NY, USA. **Mercury dynamics in aquatic food webs of the Finger Lakes, New York.**

Contamination of aquatic food webs by mercury (Hg) remains one of the most pressing global environmental issues. Mercury methylation is a detoxifying mechanism of sulphate reducing bacteria that results in the production of methylmercury (MeHg), the organic form of Hg that bioaccumulates in living organisms. The concentration of Hg in top predators is a function of many factors, including the bioavailability of MeHg, food web structure, and fish growth rates. The Finger Lakes in New York are a series of glacially formed lakes of varying depths, trophic statuses, and land uses. Little information is available on Hg biomagnification in the Finger Lakes, and MeHg concentrations are unavailable for organisms at the base of Finger Lakes food webs. From May - October 2015, we sampled suspended particulate matter, zooplankton, benthos, and fish in five of the Finger Lakes (Honeoye, Canandaigua, Seneca, Cayuga, and Owasco Lakes) on a monthly basis. Fish were targeted from all trophic levels. Here we present total Hg concentrations for fishes in all five lakes, and MeHg concentrations in seston, zooplankton, and benthos. We also assess the effect of water quality, including dissolved organic carbon, tributary inputs, and land use as predictors of lake food web Hg concentrations. *Keywords: Methylmercury, Seston, Fish, Zooplankton, Benthos.*

GATES, O.C.[1], CHANNELL, K.[1], BROWN, D.A.[1], BAULE, W.J.[1], GIBBONS, E.H.[1], SCHWAB, D.J.[1], RISENG, C.M.[1], and GRONEWALD, A.D.[2], [1]University of Michigan, Ann Arbor, MI, 48104, USA; [2]Great Lakes Environmental Research Laboratory, 4840 South State Street, Ann Arbor, MI, 48108, USA. **Great Lakes Adaptation Data Suite: Climate Data Focused on Adaptation Decision-Making.**

Climate change poses significant risks and impacts to communities across the Great Lakes region. Inherent in preparing for existing and anticipated changes in our climate is a need for locally relevant and highly credible data and distilled information. This scientific study integrates over-land observational data (National Centers for Environmental Information (NCEI): Global Historical Climatology Network (GHCN)-monthly, GHCN-daily, & Climate Division data) with over-lake and coastal observational data from Great Lakes Observing System (GLOS)/Great Lakes Environmental Research Laboratory (GLERL) observational data. Standardizing the timestep, variables, and data structure of these various data sets will increase understanding of lake, nearshore/coastal interactions for climate adaptation efforts. The development of this standardized data suite will reduce data acquisition and processing for future researchers, creating more opportunities for applying lessons from these data sets to policy decisions, and creating a single data suite available to climate adaptation practitioners and information providers across the region.

Keywords: Climatic data, Atmosphere-lake interaction, Great Lakes basin.

GAZENDAM, E., GHARABAGHI, B., ACKERMAN, J.D., and WHITELEY, H., University of Guelph, Guelph, ON, N1G 2W1, CANADA. **Stream-Habitat Assessment Tool for Restoration Projects.**

Stream-habitat assessment for evaluation of restoration projects requires the examination of watershed and reach scale parameters to incorporate the complex non-linear effects of geomorphic, riparian, hydrologic and watershed factors on aquatic ecosystems. These factors can have a significant effect on benthic habitat in stream systems. Rapid geomorphic assessment tools seldom include watershed-level parameters. Artificial Neural Network (ANN) models were developed to integrate complex non-linear relationships between the aquatic ecosystem health indices and key watershed and reach parameters. Physical stream parameters, based on QHEI parameters, and watershed characteristics data were collected at 112 sites on 62 stream systems in Southern Ontario. Benthic data were collected separately and Hilsenhoff's Biotic Index (HBI) and Richness, were determined. After training and validation, R2 values were 0.86 for HBI and 0.92 for Richness. Sensitivity analysis revealed that Richness was directly proportional to Erosion and Riparian Width and inversely proportional to Floodplain Quality and Substrate parameters. HBI was directly proportional to Velocity Types and Erosion and inversely proportional to Substrate, %

Treed and 1:2 Year Flood Flow parameters. ANN models can be useful tools for watershed managers in stream assessment. *Keywords: Artificial Neural Networks, Stream Assessment, Benthic Indices.*

GEORGE, E.G.[1], STOTT, W.[2], YOUNG, B.P.[1], KARBOSKI, C.T.[4], BIESINGER, Z.[5], ROSEMAN, E.F.[2], LANTRY, B.[4], HARE, M.P.[1], CRABTREE, D.L.[3], and RUDSTAM, L.G.[1], [1]Cornell University, Department of Natural Resources, 110 Fernow Hall, Ithaca, NY, 14853, USA; [2]USGS Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105, USA; [3]The Nature Conservancy of New York, 1048 University Ave., Rochester, NY, 14607, USA; [4]USGS Lake Ontario Biological Station, 17 Lake St., Oswego, NY, 13126, USA; [5]USFWS Lower Great Lakes Fish and Wildlife Conservation Office, 1101 Casey Rd., Basom, NY, 14013, USA. **Spawning Behavior and Early Life History of Cisco in Chaumont Bay, Lake Ontario.**

Cisco *Coregonus artedi* are an important prey fish for many Great Lakes predators, although their numbers have declined in the last century due to overfishing, habitat degradation, and invasive species. Chaumont Bay contains the last known spawning population of cisco in New York waters of Lake Ontario. Beginning in 2013, several studies on spawning behavior, habitat preferences, larval abundance, and other life history characteristics of the Chaumont Bay population were initiated. Otolith analysis showed that the population is dominated by a few strong year classes. Egg pumping and egg mat surveys showed that cisco display a strong preference for shallow, rocky shoal areas. In 2014 the first confirmed cisco larvae in the bay in decades were collected using light traps and neuston nets. Larvae were widely distributed in high densities around the bay, and after hatching moved quickly into nearshore locations away from spawning shoals. Identification of the larvae by traditional visual means was confounded by a large overlap in morphometrics with lake whitefish *C. clupeaformis*: when using standard keys, >80% of Chaumont Bay cisco had the potential to be misidentified as lake whitefish. The results from these studies will be used to guide future cisco restoration efforts in Lake Ontario. *Keywords: Fish, Coregonines, Fish populations, Spawning, Lake Ontario, Native species.*

GEZON, N.R.[1], STRYCHAR, K.B.[1], and HEWSON, I.H.[2], [1]Annis Water Resources Institute Grand Valley State University, 740 W. Shoreline Dr., Muskegon, MI, 49441, USA; [2]Department of Microbiology Cornell University, Ithaca, NY, 14853, USA. **Understanding viral pathogens and their role in Diporeia decline in Lake Michigan.**

Diporeia are an ecologically and biogeochemically important native amphipod species found throughout the Laurentian Great Lakes. Their populations have experienced major declines throughout Lake Michigan, Huron, and Ontario potentially due to several factors including competition with invasive dreissenid mussels and disease. A pathogenic circovirus identified by Hewson et al. 2013 (LM29173) may have played an as yet poorly constrained role in its demise, yet its origins are not currently known. In this study, sediment cores will be taken in several locations across the Great Lakes where Diporeia populations were historically abundant. The abundance of circoviruses will be quantified in vertical core horizons, which correspond to a chronosequence of deposition. Results will identify the appearance of the LM29173 circovirus in time, to understand whether its presence in the lakes occurred during times of largest Diporeia population declines. *Keywords: Lake Michigan, Sediments, Viruses, Amphipods.*

GIBBONS, E.H., GRACE, A., SIMS, J., BROWN, D.A., BRILEY, L.J., and GATES, O.C., Graham Sustainability Institute/ University of Michigan, 625 East Liberty Street, Suite 300, Ann Arbor, MI, 48104, USA. **Cities Impacts & Adaptation Tool: Climate Data Localization & Resources for Great Lakes Communities.**

The Great Lakes Integrated Sciences + Assessments (GLISA), a cooperative effort between the University of Michigan and Michigan State University, functions as a bridge between climate science researchers and boundary organizations in the Great Lakes region, with the goal of contributing to the long-term sustainability of the region in face of a changing climate and to facilitate smart decision-making backed by sound scientific knowledge. From a community/regional standpoint, making climate information relevant at the local level is key to stakeholders and decisions makers. The focus of the presentation will be the University of Michigan Climate Center's Cities Impacts and Adaptation Tool (CIAT) and how this tool can be used to access localized information. The CIAT allows decision makers at the city level to access information such as: demographics, socioeconomic data, and historical/projected climate information and trends. Using this information, decision makers are able to identify a network of climate peers whose current climate reflects the projected climate for the specified location. Decision-makers also have access to a database of existing climate action plans from across the country, through the CIAT, to incorporate existing knowledge in their own operations. *Keywords: Urban areas, Climate change, Planning.*

GIBERSON, G.[3], WELLEN, C.C.[2], ONI, S.[1], and OSWALD, C.[3], [1]Swedish Agricultural University, Umeå, SWEDEN; [2]University of Waterloo, Waterloo, CANADA; [3]Ryerson University, Toronto, CANADA. **Chloride Storage Across a Gradient of Urban Watersheds in Southern Ontario, Canada.**

In seasonally frozen environments such as Canada, de-icers (chloride salts) are widely used to maintain safe driving conditions. While the beneficial role of winter salt usage for public safety is unequivocal, recent studies suggest that chloride accumulates in watersheds causing summer baseflow concentrations to approach chronic exposure levels. In this study, we carry out watershed-scale chloride mass balance estimates for multiple urbanizing watersheds in southern Ontario. Chloride inputs to the study watersheds are estimated using municipal, regional/provincial road salt usage data coupled with geospatial information on road length and classification. While our mass balance calculations are designed to estimate the mass of chloride storage within each watershed they also incorporate significant uncertainty related to inputs of chloride salts for winter maintenance on private properties. To address this uncertainty, we use geospatial analysis of remote sensing imagery to estimate privately-owned impervious areas and apply a range of salt application rates to these areas to determine potential private inputs. The results of our mass balance estimates are used to examine the timing and magnitude of chloride movement through a watershed with respect to the extent, topology and connectivity of impervious areas. *Keywords: Water quality, Urban ecology, Road salt.*

GINN, B.K., COULOMBE, D., and BOLTON, R.P., Lake Simcoe Region Conservation Authority, Newmarket, ON, CANADA. **Zebra to quagga mussels: impacts of species change/ habitat expansion on benthos and coldwater fish.**

Since 2010, we have recorded a rapid decline in the population of zebra mussels (*Dreissena polymorpha*) in Lake Simcoe, an invasive species that since their arrival in 1995, has increased complexity in benthic habitats, shunted energy cycling toward the nearshore and benthos, and extirpated native mussels. As in some Great Lakes (Erie, Michigan, Ontario), this decline in zebra mussels has coincided with the expansion of its congener, the quagga mussel (*D. rostriformis bugensis*). Using annual monitoring of benthos, and two lake-wide, >700 site, mussel-specific, surveys in 2009 and 2015, we have quantified the extent of this species shift and expansion into soft substrate profundal habitats. Currently, we are investigating the consequences of this species change on the profundal benthos and coldwater fish communities, changing patterns of trophic energy flow, and implications of these changes to our lake management strategies. *Keywords: Dreissena, Quagga mussels, Zebra mussels, Benthos.*

GÍSLASON, D., ROBINSON, B., and MCLAUGHLIN, R.L., University of Guelph, 50 Stone Road E., Guelph, ON, N1G 2W1, CANADA. **A comparative test of harvest-induced change in length at maturation for four Lake Erie fishes.**

Harvesting can alter the life history traits of fish stocks. Harvest-induced decreases in age and size at maturation are particularly important because maturation affects size later in life, and therefore fecundity and production. We used a model of life history plasticity to test for harvest-induced change in length at 50% maturation (L50) for four species of freshwater fish from Lake Erie: two species where harvest is tightly regulated, Yellow Perch (*Perca flavescens*) and Walleye (*Sander vitreus*), and two species where harvest in not regulated, White Perch (*Morone americana*) and White Bass (*Morone chrysops*). Between 1991 and 2010, L50 varied widely in all four species. Contrary to expectations from the model of life history plasticity, for all four species we found no evidence that increasing harvest rate of reproductive individuals resulted in (i) reduced juvenile densities, (ii) increased juvenile growth rates due to reduced competition, and (iii) lower L50 due to faster growth rates. However, temporal changes in L50 were synchronous across the four species, even though harvest rates and adult abundances were not. We speculate that the changes observed in L50 across the four species are the outcome of large-scale ecosystem changes unrelated to harvesting. *Keywords: Fishing, Life history studies, Lake Erie.*

GIVENS, C.E.[1], DURIS, J.W.[1], STELZER, E.A.[1], ECKER, C.D.[1], LARSON, J.H.[2], LOFTIN, K.[3], LENAKER, P.[4], and EVANS, M.A.[5], [1]USGS Michigan-Ohio Water Science Center, Lansing, USA; [2]USGS Upper Midwest Environmental Sciences Center, La Crosse, WI, USA; [3]USGS Kansas Water Science Center, Lawrence, KS, USA; [4]USGS Wisconsin Water Science Center, Middleton, WI, USA; [5]USGS Great Lakes Science Center, Ann Arbor, MI, USA. **Changes in Bacterial Communities in Relation to Harmful Algal Bloom Formation and Toxin Occurrence.**

The occurrence of cyanobacterial harmful algal blooms (cyanoHABs) in freshwater systems continues to be a human and environmental health problem in the Great Lakes region. In 2014, we began characterizing the life cycle of HABs, including toxin occurrence, the genes responsible for cyanotoxin production, and associated microbial communities in the western basin of Lake Erie. Next-generation 16S-metagenomic sequencing was used to assess the bacterial community in the sediment and water column. This sequencing provides a focused analysis of overall bacterial and cyanobacteria community succession in blooms. Analysis of the sediment microbial community supports the hypothesis that cyanobacteria overwinter in the sediment and act as a source population for summer cyanoHABs. Understanding how microbial populations change over time, combined with water-quality data, will be used to identify potential triggers for cyanoHABs and cyanotoxin production. In 2015, this work was expanded to include a shotgun metagenomic sequencing approach to evaluate potential functional capabilities of bacterial communities during bloom formation. Understanding the structure and function of bacterial communities associated with cyanoHABs is essential to understanding how biotic and abiotic factors impact bloom formation and toxin production. *Keywords: Harmful algal blooms, Microbiological studies, Great Lakes Restoration Initiative (GLRI).*

GOLMOHAMMADI, G.[1], RUDRA, R.P.[1], PRASHER, S.[2], MADANI, A.[2], MOHAMMADI, K.[1], and GOEL, P.[3], [1]School of Engineering, University of Guelph, Guelph, ON, CANADA; [2]McGill University, Montreal, CANADA; [3]Ontario Ministry of the Environment and Climate Change, Etobicoke, CANADA. **Assessing Tile Drainage Impact on Water Budget and Sediment Yield in an Agricultural Watershed.**

Recently, DRAINMOD model was incorporated into Soil and Water Assessment Tool (SWAT) as an alternative tile flow and water table depth simulation methods and as well as a tool to design cost-effective tile drain water management systems. The newly developed model, SWATDRAIN, was used to assess changes in water balance components, discharge, and sediment loads due to tile drainage practices in a heavily tile drained watershed in Ontario, Canada. Three scenarios of conventional drainage (existing condition), controlled drainage, and no tile drainage implemented across the watershed were examined. Simulations were carried out over the period from 1975 to 1984; the 1975-1979 data were used for model calibration and the 1980-1985 data were used for validation Model accuracy statistics for monthly streamflow and sediment loads over the validation period were 83% and 74% for the Nash Sutcliffe Efficiency. SWATDRAIN model predicted a 17 % increase in sediment loads from the basin due to controlled drainage. *Keywords: SWATDRAIN, Grand River, DRAINMOD, Sediment load, SWAT, Modeling.*

GOLMOHAMMADI, G.[1], RUDRA, R.P.[1], GOEL, P.[2], and DICKINSON, T.[1], [1]School of Engineering, University of Guelph, Guelph, ON, CANADA; [2]Ministry of Environment and Climate Change, Etobicoke, CANADA. **Predicting the Areas Contributing Flow in an Agricultural Watershed using SWAT Model.**

This study is being conducted to assess the capability of SWAT model to identify the areas which contributing to the flow in a watershed. SWAT model was used to evaluate the hydrology at Gully Creek Watershed located in Ontario. Daily streamflow data from 12 July 2010, to 30 September 2011, were used for calibration, and the data from 1 October 2011 to 28 March 2012, were used to validate the model performance. In addition to the daily streamflow data, the flow/no flow observations were available for 18 different monitoring stations at 9 different events (162 events in total; 65 flow observed and 97 no flow observed). The calibrated model was also used to simulate the streamflow at the monitoring stations across the watershed. The simulation results at these stations were compared to the observed flow/no flow data. The results showed that 100% (65/65) of the observed flow events were predicted by the model properly, while only 50% (49/97) of the observed no flow events were predicted by the model. The impact of number of subbasins on capability of the model to predict the flow/no flow data are being studied and the results will be presented. *Keywords: Watersheds, SWAT, Assessments, Modeling.*

GOMEZ-GIRALDO, A., ROMAN-BOTERO, R., ARBELAEZ, A.C., and TORO, M., Universidad Nacional de Colombia, Sede Medellín, Facultad de Minas, Carrera 80 No 65-223 - Núcleo Robledo, Medellín, USA. **Seasonal thermal stratification of three tropical andean reservoirs.**

The dominant basin scale and season evolution of the transport processes were studied in Riogrande II, La Fe and Porce II, three mountain tropical Andean reservoirs of different altitude and bathymetry located in Colombia, South America. Eight field campaigns were conducted in each reservoir between 2010 and 2012 and data of physical variables and weather were measured. The ELCOM hydrodynamic model was used to complete the analysis. It was found that the variability of the thermal structure was dominated mainly by changes in the inflows discharge and the temperature, related to the hydrological rainfall cycle, and not by the atmospheric heat fluxes variability. The effect of the net atmospheric flux was confined to the surface mixed layer, which thickness varied between 2 and 4 m by the effect of short wave radiation heating during the day and strong heat loss starting at midafternoon and remaining through the night. The density currents from small inflows were intrusive and created an intermediate layer of young water and bottom layer of old water, while those of large inflows remained attached to the bottom and filled the reservoir from the bottom. This resulted in the thermal structure developing a bi-modal annual cycle that follows the bi-modal distribution of the rainfall and river discharge in the region. *Keywords: Tropical regions, Tropical limnology, Reservoirs, Bottom currents.*

GOODFELLOW, B. and DROUILLARD, K.G., University of Windsor, Windsor, CANADA. **Quantifying fecal egestion and assimilation efficiency in two species of fish using a dual tracer.**

Gill elimination is considered a main route of PCB elimination in fish. A dual tracer study was designed to quantify fecal egestion efficiency and assimilation efficiency of PCBs in two species of fish, rainbow trout (*Oncorhynchus mykiss*) and bluegill sunfish (*Lepomis macrochirus*). Fish were dosed with non-environmental PCBs via intraperitoneal injection and then fed a dosed meal containing a mixture of Aroclor (environmental) 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 determined according to the dual tracer approach. Results are compared with predictions from the gastroinetestinal magnification model and modified GI-magnification model to estimate the biomagnification potential and contrast PCB biomagnification in bluegill sunfish and rainbow trout. *Keywords: Bioaccumulation, Bioindicators, Bioenergetics.*

GOZUM, Z.J., KIM, D.K., PELLER, T., RAMIN, M., and ARHONDITSIS, G.B., University of Toronto Scarborough, Department of Physical & Environmental Sciences, 1265 Military Trail, Toronto, ON, M1C 1A4, CANADA. **Projecting Water Quality Trends in Cootes Paradise and Their Implications for the Hamilton Harbour.**

Cootes Paradise Marsh, a hypereutrophic wetland draining into the western end of Hamilton Harbour, has historically been considered an important regulatory factor of the severity of local eutrophication phenomena. In this study, we present a modelling exercise that aims to draw inference on the relative contribution of various external and internal flux rates to the phosphorus budget of Cootes Paradise. We first examined the capacity of a phosphorus mass-balance model, accounting for the interplay among water column, sediments and macrophytes, to reproduce the observed total phosphorus (TP) dynamics over a 17-year period (1996-2012). Water level fluctuations were one of the key challenges for balancing the phosphorus budget during model calibration. Our analysis shows that the model satisfactorily reproduced the average seasonal patterns as well as the year-to-year TP variability. Model sensitivity analysis identified the sedimentation of particulate material and diffusive reflux from sediments as two critical processes to characterize the phosphorus cycle in the wetland. We conclude by discussing the various sources of uncertainty and additional remedial actions required in Cootes Paradise marsh to realize a shift from the current turbid-phytoplankton dominated state to its former clear-macrophyte dominated state. *Keywords: Eutrophication, Macrophytes, Wetlands, Phytoplankton, Phosphorus.*

GRAY, D.K.[1], SANTMYER, C.[1], and BROWNE, M.A.[2], [1]Department of Biological and Environmental Sciences, California University of Pennsylvania, 250 University Avenue, California, PA, 15419, USA; [2]Evolution and Ecology Research Center, University of New South Wales, Sydney, AUSTRALIA. **Rapid accumulation of plastic debris on southern Lake Erie beaches.**

The presence of plastic debris in the Great Lakes is a well-known problem, but few studies have been conducted to determine how much plastic waste is accumulating on surrounding beaches. This study had two main objectives: 1) to determine the rate of accumulation of plastics on Lake Erie beaches; and 2) to identify the types of plastic debris found on those same beaches. We selected eight beaches along the southern shoreline of Lake Erie for our survey. The beaches were sampled monthly during June-August of 2014. Plastic debris accumulated quickly after each beach was cleaned (up to 19 pieces or 34.9 g m-2d-1). The most common items collected were plastic fragments (1-5cm), expanded polystyrene pieces (1-5cm) and plastic cigar tips. The abundance of expanded polystyrene and cigar tips suggests that efforts to reduce plastic debris in Lake Erie should target beachgoers that bring food containers and cigars to the beach. *Keywords: Beaches, Plastic, Pollutants.*

GRAY, S.M.[1], MCDONNELL, L.H.[2], MANDRAK, N.E.[3], and CHAPMAN, L.J.[2], [1]The Ohio State University, 2021 Coffey Rd, Columbus, OH, 43210, USA; [2]McGill University, 1205 ave Docteur Penfield, Montreal, QC, H3A 1B1, CANADA; [3]University of Toronto Scarborough, 1265 Military Trail, Toronto, ON, M1C 1A4, CANADA. **The Influence of Turbidity on the Physiology of Imperiled Blackline Shiners in the Great Lakes.**

Increased sedimentary turbidity associated with human activities is often cited as a key stressor contributing to the decline of fishes globally. The mechanisms underlying negative effects of turbidity on fish populations are not well understood, but may include effects on behavior (e.g. visual impairment) and/or respiratory function (e.g. clogging of the gills). The decline or disappearance of several blackline shiners (*Notropis* spp.) in the Laurentian Great Lakes has been associated with increased turbidity. Here, we used non-lethal physiological methods to assess the responses of three blackline shiners (*N. anogenus, N. bifrenatus, N. heterolepis*) to increased turbidity. Fish were exposed for 3-6 months to continuous low levels of sedimentary turbidity (~10 NTU). To test for effects on respiratory function, we measured resting metabolic rate and critical oxygen tension (the oxygen partial pressure at which the resting metabolic rate of fish declines). Our preliminary analyses suggest that critical oxygen tensions are negatively affected by long-term exposure to turbidity in imperiled Pugnose and Bridle, but not the more abundant Blacknose Shiner. These results indicate interspecific variation in the effects of turbidity on respiratory performance, which may contribute to the current status of the three species. *Keywords: Fish management, Endangered species, Turbidity, Conservation, Fish, Notropis spp..*

GREAVES, A.K.[1], SU, G.[2], and LETCHER, R.J.[2], [1]Carleton University, 1125 Colonel By Drive, Ottawa, ON, K1S5B6, CANADA; [2]National Wildlife Research Centre; Environment and Climate Change Canada, 1125 Colonel By Drive, Ottawa, ON, K1S5B6, CANADA. **In Vitro Metabolism of Organophosphate Triester Flame Retardants in Herring Gulls (*Larus argentatus*).**

Recently, we reported the accumulation and distribution of organophosphate (OP) triester flame retardants (FRs) in six body compartments of female herring gulls (*Larus argentatus*) from Lake Huron. ΣOP concentrations were highest in fat, and not detected in liver, suggesting rapid metabolism. In the present study, OP triester FR metabolism and kinetics were investigated in the same gulls. Microsomal fractions were isolated from enzymatically viable liver tissue. Microsomal suspensions were administered a wide range of concentrations (0.01µM - 10µM) of six OP triesters of environmental relevance: TDCIPP,

TPHP, TBOEP, TNBP, TCIPP, and TEP. Enzyme kinetic parameters were determined for all OPs. Subsequently, *in vitro* assays quantified OP triester metabolism and corresponding OP diester formation over a 100 minute incubation period. All OP triesters (with the exception of TEP) were rapidly metabolized, with aliphatic triesters generally being metabolized faster than halogenated triesters. The conversion of OP triesters to their respective diesters varied greatly by compound (9 - 90% conversion of initial triester dose).This demonstrated some structure-dependency for the metabolism of OP triesters by herring gulls, which was also consistent with persistent residue levels in free-ranging gulls.
Keywords: Metabolism, Organophosphate Flame Retardants, Biotransformation, Herring Gull, Environmental contaminants, Liver microsomes.

GREEN, P.A. and HENQUINET, J.W., National Park Service, 800 East Lakeshore Drive, Houghton, MI, 49931, USA. **Emergency treatment of ballast for aquatic invasive prevention: Moving beyond testing to treatment.**

Emergency treatment of ballast for aquatic invasive prevention: Moving beyond testing to treatment. In 2014, the NPS USGS and industry consortium completed efficacy trials of a novel ballast treatment system that can be deployed on and off multiple ships and started training emergency responders that could implement treatment within emergency response time frames. Critical pieces are in place to facilitate and prevent or respond to AIS outbreaks. This presentation will compare efficacy results to those achieved via exchange, the current best management practices; opportunities for risk reduction through deployment, and status of efficacy testing in collaboration with the Canadian Shipowners Association.
Keywords: Biological invasions, Ballast, Environmental policy.

GREGORY, M.A., Computational Hydraulics International (CHI), 147 Wyndham St. N., Suite 202, Guelph, ON, N1H 4E9, CANADA. **Financial Incentives for Green Infrastructure Through Stormwater User Fees.**

There are attractive environmental and social benefits for residents and business owners who install Green Infrastructure facilities on their properties. However, demonstrating a reasonable payback period remains a challenge. Further, traditional design objectives, and the corresponding criteria for establishing user fee credits, rely on the use of event-based hydrology which is limited in its ability to assess potential impairment to downstream receiving watercourses. This presentation offers a new methodology using continuous hydrologic simulation that can complement an existing credit program by rewarding property owners with on-site facilities that can demonstrate improved flow duration control compared to pre-development conditions. Flow duration compliance criteria were developed that distinguish sites with vastly different runoff response characteristics. The methodology is demonstrated for three project examples that bracket a wide range of LID installations, including: the construction of a new infiltration gallery located on a site where soils are conducive to infiltration; the retrofit of an existing rooftop drainage system for consumptive use of stormwater on a site where soils do not allow infiltration; and an industrial site development that features bioretention cells and infiltration trenches. *Keywords: Hydrodynamic model, Ecosystem health, Urbanization.*

GRIMM, A.G.[1], BROOKS, C.N.[1], BINDER, T.R.[2], KRUEGER, C.C.[3], RILEY, S.C.[4], and SHUCHMAN, R.A.[1], [1]Michigan Tech Research Institute, Michigan Technological University, 3600 Green Ct. Ste. 100, Ann Arbor, Mi, 48105, USA; [2]Department of Fisheries and Wildlife, Michigan State University, Hammond Bay Biological Station, 11188 Ray Rd., Millersburg, Mi, 49759, USA; [3]3Great Lakes Fishery Commission, 2100 Commonwealth Blvd., Ste. 100, Ann Arbor, Mi, 48105, USA; [4]U.S. Geological Survey, Great Lakes Science Center, 1451 Green Rd., Ann Arbor, Mi, 48105, USA. **Identification of likely Lake Trout spawning habitat using multispectral remote sensing.**

Natural reproduction by lake trout Salvelinus namaycush has recently increased in Lake Huron, but knowledge of early life history, including spawning locations, is currently incomplete. Remote sensing offers a method of identifying likely shallow spawning habitats within the lake's large littoral zone for further study, thereby supporting the efficient allocation of field monitoring resources. The spectral characteristics of shallow, rocky reefs located in the Drummond Island Refuge were obtained from Pléiades multispectral satellite imagery collected before and after the beginning of the 2013 spawning season, and sites that did and did not contain lake trout eggs as determined by diver surveys were compared. While the distribution of field data limited the assessment of the ability to distinguish among degrees of vegetation density and detect changes in vegetation density over time, a binomial regression model based on the above characteristics was reasonably accurate at predicting the locations of active spawning areas as confirmed by egg survey data. Combined with recent findings on the geological formations associated with lake trout spawning, vegetation mapping and change detection represents a new potential tool for locating spawning habitat. *Keywords: Lake trout, Habitats, Remote sensing.*

GRIMSTEAD, J.P., ARMANINI, D.G., and YATES, A.G., The University of Western Ontario, 1151 Ricmond St, London, ON, N6A5C2, CANADA. **Thresholds in Benthic Macroinvertebrate Communities Associated with Agricultural Land Use Patterns.**

Agricultural land use affects benthic macroinvertebrate (BMI) community structure but riparian forest may mitigate its impact. BMI communities were sampled in small streams

within the Grand River watershed in southwestern Ontario. The study assessed the effects of the location and amount of agricultural land use on variation in BMI assemblage structure. Three land use distribution scenarios were evaluated to isolate specific ranges of agricultural land use at either the riparian or catchment scale, with the adjoining scale covering as wide a gradient of agricultural land use as possible. The riparian forest is expected to mitigate the effects of agricultural land use until a land cover threshold is surpassed, triggering a shift in the composition of the BMI community to one consisting of more tolerant taxa. Identification of agricultural land cover thresholds will inform governing authorities drafting land-use policies as well as contribute towards enhanced bioassessment and biomonitoring programs through the establishment of biocriteria for areas lacking near pristine reference sites. *Keywords: Benthic Macroinvertebrates, Agriculture, Watersheds, Thresholds.*

GROFF, C.M., KASTER, J.L., and KLUMP, J.V., University of Wisconsin-Milwaukee School of Freshwater Sciences, 600 E. Greenfield Avenue, Milwaukee, WI, 53204, USA. **Dreissenid Mussels, Freshwater Microbialites, and Nutrient Enrichment in Mexico's Laguna Bacalar.**

Laguna Bacalar, Quintana Roo, MX, is one of the most visually stunning lakes on the planet. Extensive growths of living thrombolytic microbialites, representative of the oldest known life-forms on Earth, thrive in its turquoise waters. The Laguna Bacalar specimens have existed since the Holocene, and are suggested to comprise the largest living formations on the planet. *Mytilopsis sallei*, marine dreissenid native to the Caribbean rim, colonizes microbialite surfaces and can also be found totally encapsulated within the microbialite structure, suggestive of a symbiotic relationship. Mussel populations appear to have been limited by low phytoplankton abundances, allowing for a relative ecological coexistence with microbialites. Over the past decade, the area has begun to experience significant human population growth as tourism advances south from the Riviera Maya. Based on 2015 data, mussel densities are currently estimated to be near 2,500/m^2 in some areas. The associated influx of nutrients to the laguna due largely to inadequate sewage treatment may increase phytoplankton and thus dreissenid populations, potentially detrimental to microbialites. These processes may yet be curbed with collection and communication of scientific data, elevating global awareness of the importance of this world-class ecosystem.
Keywords: Dreissena, Biological invasions, Conservation, Microbiological studies, Environmental ethics, Benthos.

GUDIMOV, A., KIM, D.K., ALLERTON, M.L., CHENG, V., and ARHONDITSIS, G.B., University of Toronto Scarborough, Department of Physical & Environmental Sciences, 1265 Military Trail, Toronto, ON, M1C 1A4, CANADA. **Probabilistic Assessment of Nutrient Baseline Export in Lake Simcoe Watershed with SPARROW Model.**

After two centuries of deforestation and urbanization, Lake Simcoe currently experiences re-oligotrophication processes induced by a nutrient reduction program that targets phosphorus input of 42 TP kg/year by 2045. The present socio-environmental catchment analysis quantifies the baseline nutrient tributary export using SPARROW modelling. We estimate spatial variability of nutrient loads, export coefficients and delivery rates from the different sub-catchments. We developed a Bayesian hierarchical framework and our work shows how literature information or knowledge gained from adjacent watersheds can be used to overcome the problem of inadequate data quantity and quality. The potential bias introduced from the pertinent assumptions is examined by quantifying the relative change of the parameter estimates after model calibration. We quantify the degree of reliance of our exercise upon literature information, and evaluate the actual contribution of the available data to the inference drawn by the model. Other important questions that are addressed by our exercise are as follows: What is the relative impact of agricultural and urban land uses? What is the background loading exported by the forested areas? What is the likelihood that increasing urbanization in the watershed will impact the water quality in Lake Simcoe. *Keywords: Phosphorus, SPARROW, Watersheds, Adaptive management, Tributaries.*

GUIASU, R.C. and MCNEIL, T., Glendon College, York University, 2275 Bayview Avenue, Toronto, ON, M4N3M6, CANADA. **Why Is Purple Loosestrife on the IUCN's 100 of the World's Worst Invasive Species List?**

Purple loosestrife (*Lythrum salicaria*) is listed as one of the world's worst invasive species by the World Conservation Union (IUCN). Expensive control programs are undertaken against this wetland plant in North America, including the Great Lakes region. A thorough review of the relevant scientific literature has revealed that the anti-purple loosestrife programs and propaganda may not be well-supported, overall, by the available evidence and studies on the actual impact of this plant on North American wetland ecosystems. Given this discrepancy, we analyzed the criteria for the inclusion of this, and some other Great Lakes species, on influential lists of invasive species, such as those published or disseminated by the IUCN and the Ontario's Invading Species Awareness Program. We argue that the reasons why some species are found on these lists are sometimes unclear. The presence of some of these species on such lists may not always accurately reflect the proven impact of these animals and plants in the ecosystems where they may have been introduced. *Keywords: Biological invasions, Invasive species, Wetlands.*

GUILDFORD, S.J.[1], VERBURG, P.[2], and HECKY, R.E.[1], [1]University Minnesota Duluth, Large Lakes Observatory, Duluth, USA; [2]National Institute Water & Atmosphere, Hamilton, NEW ZEALAND. **Evidence of P Deficiency in an N limited Great Lake.**

Lake Taupo, iconic for its dramatic volcanic setting and crystal clear waters (mean annual chlorophyll 1 μg/L, Secchi 15 m), is New Zealand's largest (612 km^2, 167 m max. depth) and its only Great Lake. Taupo is the only large lake in the world currently under a nitrogen (only) loading cap operating since 2011 (cap based on 2001 loading) to protect the lake's water quality. The choice to cap N was based on low TN:TP, low NO_3:SRP and enrichment bioassays most recently done in 2001 which concluded that N limited algal growth in Lake Taupo. We evaluated the nutrient status of Taupo in Jan.-Feb. 2015 and found strong evidence of P deficiency whereas none had been found in 2001. Chl a has also remained low despite evidence for increased N concentration since 2001. Taupo phytoplankton are now more deficient in P than in 2001, and P as well as N may be limiting algal biomass. The TN:TP molar ratio in Lake Taupo is approximately 37 which is in the range (20-50) where our previous studies in lakes and oceans have indicated that both N or P deficiency can occur. *Keywords: Nutrients, Phytoplankton, Eutrophication.*

GUILLARD, J.[1], ANNEVILLE, O.[1], and YULE, D.L.[2], [1]INRA, 75 avenue de Corzent, Thonon, 74200, FRANCE; [2]U.S. Geological Survey, 2800 Lakeshore Drive, Ashland, WI, 54806, USA. **Assessing food availability of coregonid larvae with acoustic methods in large deep lakes.**

As a cold-water adapted family, coregonids are sensitive to climate change. Coregonid year-class strength is largely determined by survival of larvae that feed on zooplankton upon hatching. Measuring the spatial distribution and temporal dynamics of zooplankton in large lakes with a limited number of net tows may not accurately capture the foraging arena experienced by larvae. There is a growing body of research demonstrating that zooplankton biomass can be estimated with single frequency and multiple-frequency acoustic approaches. By pairing net tows with acoustic sampling at study sites in Lake Geneva (France-Switzerland) and Lake Superior (USA-Canada) we hope to develop a rapid technique for assessing the zooplankton community important to larvae. Five frequencies will be tested (38, 70, 120, 208 and 420 kHz). Larvae will be collected with surface trawls to test the hypothesis that larvae and zooplankton distributions are spatially correlated. Our goal is to advance assessment of larval food availability over broad spatial scales using acoustic methods. The development of a tool to rapidly assess the quality of habitat for larval coregonids could inform coregonid restoration and conservation activities, and be used to model larval growth to predict how a changing lake environment may affect larvae survival. *Keywords: Zooplankton, Acoustics, Fish.*

GUO, J., VENIER, M., SALAMOVA, A., LIU, L.Y., and HITES, R.A., Indiana University, 702 N. Walnut Grove Ave., Bloomington, IN, 47405, USA. **Flame Retardants Distribution in the Great Lakes Atmosphere and Fish.**

We measured 83 flame retardants (and related compounds) in the atmosphere and in fish from the Great Lakes. A total of 29 air samples, including both particle and vapor phases, were sampled in January, April, July, and October of 2013 from six Integrated Atmospheric Deposition Network (IADN) sites. Lake trout (or walleye for Lake Erie) were collected in triplicate in 2010 from each of the five Great Lakes. Polybrominated diphenyl ethers (PBDEs) were abundant in both air and fish; their concentrations ranged from 2 to 71 pg/m^3 and 125 to 495 ng/g lipid weight (lw), respectively. Hexabromocyclododecanes (sum of α, β, and γ isomers) were found at high concentrations in fish at several sites; their geometric mean concentration was 33 ng/g lw. Of the Dechlorane like compounds, HCPN, Mirex, Dec-602, Dec-604CB, Br-Dec-604, Br_2-Dec-604, and Cl_4-Dec-604 were detected frequently in fish samples. HCPN and Mirex were found in all air samples with geometric mean concentrations of 0.5 pg/m^3 and 0.08 pg/m^3, respectively. The total concentrations of 18 organophosphate esters were 100-1,800 ng/g lw for fish and 45-4,300 pg/m^3 for air. TCEP, TPhP, TnBP, and TPEP were most abundant in fish, while TCEP, TPhP, TCIPP, and TDCIPP were most abundant in air. *Keywords: Fish, Environmental contaminants, IADN.*

GUO, J.[1], CREED, I.F.[1], and BUTTLE, J.M.[2], [1]Department of Biology, Western University, London, ON, N6A 5B7, CANADA; [2]Department of Geography, Trent University, Peterborough, ON, K9J 7B8, CANADA. **Hydrological landscape classification assess flow regime to climate variability in Ontario, Canada.**

Hydrological classification plays an important role in ecohydrology as both an organizing framework and scientific tool for environment flow assessment. Here we use a hydrological landscape classification (HL) to evaluate effects of climate variability on streamflow regime in Ontario, Canada. The HL classification consists of five indices: climate, seasonality, aquifer permeability and terrain and soil permeability. A multivariate regression tree was used to relate flow regime to the fractional coverage of HL within the watershed for gauged stream in 1981-1990, and grouped 114 gauged watersheds into 11 classes. We assess climate variability on flow regime when the 1981-1990 HL climate indices are recalculated using 1991-2000 and 2001-2010 historic data. Results showed climate class was stable for most area, but northwestern Ontario got wetter, as did the zone north of Lake Superior and southwestern Ontario got drier. In contrast, seasonality were more variable at the regional scale, especially in 2001-2010 more directions and areas of seasonality changed were observed. Clear regional shift patterns of flow regime because of climate change were observed indicating the differing flow regime response to environmental variability within different watersheds. The results can help inform management response to climate change *Keywords: Hydrological landscape classification, Watersheds, Flow regime, Climate change, Great Lakes basin.*

H

HAAK, D.M.[1], KOWALSKI, K.P.[2], MOORE, C.T.[1], and DASILVA, A.[2], [1]Georgia Cooperative Fish and Wildlife Research Unit, Athens, GA, USA; [2]U.S. - Geological Survey - Great Lakes Science Center, Ann Arbor, MI, USA. **Introducing the *Phragmites* Adaptive Management Framework (PAMF).**

About 24,000 hectares of Great Lakes shoreline is infested with non-native Phragmites, and another 340,000 hectares are at risk. Management resources are available to guide the treatment selection process (e.g. local best management practices) but do not account for variation based on local conditions or uncertainties about plant response to treatments. The Phragmites Adaptive Management Framework (PAMF) is being developed to facilitate a landscape change in management strategy and is seeking stakeholder participation. Once fully operational, resource managers involved in PAMF will monitor the response of Phragmites to a treatment, upload results to a centralized database, and then receive annual, customized guidance suggesting what action is most likely to achieve objectives in the next round of treatments. PAMF will unite resource managers, researchers, and other stakeholders in the Great Lakes in an effort to promote enduring conservation by establishing and furthering cooperation and transparent decision making in the face of uncertainty. This cooperative effort is a more cost- and time-efficient approach for the stakeholder than a 'go it alone' approach. PAMF will enable resource-managers in the Great Lakes basin to better control invasive Phragmites and benefit from the learning that occurs from a regional effort. *Keywords: Invasive species, Coastal wetlands, Management.*

HAMIDI, S.A.[1], BRAVO, H.R.[1], MCLELLAN, S.[1], HAHN, M.[2], and LORENZ, D.J.[3], [1]University of Wisconsin-Milwaukee, Milwaukee, WI, USA; [2]Southeastern Wisconsin Regional Planning Commission, Waukesha, WI, USA; [3]University of Wisconsin-Madison, Madison, WI, USA. **Impacts of climate change on the transport of bacteria in Great Lakes urban coastal waters.**

Climate change can affect the patterns of circulation and transport of pathogens in Great Lakes coastal waters. Planning for infrastructure renewal, allocation of resources for public health, recreation and restoration efforts requires the prediction of climate change effects. The UW Madison Center for Climatic Research created downscaled climate change

data for meteorological stations around Milwaukee and Lake Michigan. The Southeastern Wisconsin Regional Planning Commission (SEWRPC) and Tetra Tech implemented a hydrologic model that predicts flows and bacteria loads for the tributary watersheds. A hydrodynamic and bacteria transport model was developed at UW Milwaukee for this study. Important scientific questions addressed in this study were: 1) the representation of physically correct climate change scenarios to study the impacts on tributary flows and bacteria loads, circulation and transport in Lake Michigan coastal waters, 2) the selection of simulations periods, and 3) addressing uncertainty in climate change predictions.
Keywords: Climate change, Lake Michigan, Hydrodynamic model.

HANCOCK, H.[1], SINCLAIR, C.[1], KURISSERY, S.[1], MURRAY, C.[1], STEPHEN, D.[2], and KANAVILLIL, N.[1], [1]Lakehead University, 500 University Avenue, Orillia, ON, L3V 0B9, CANADA; [2]Environmental Services, Ramara Township, Brechin, ON, CANADA. **Characterization of the Trophic Status in Lagoon City water canals, Brechin, Ontario.**

Water quality in the canals of Lagoon City, Ontario, a man-made water system on the east shore of Lake Simcoe, has recently demonstrated symptoms of eutrophication due to rapid growth of algae and other aquatic vegetation. A water quality study has been conducted between June-October, 2014 by collecting water samples in a monthly interval. In addition, a weekly sampling took place in the month of August to understand the weekly changes of water qualities in this water system. The parameters monitored were pH, conductivity, temperature, total suspended load, dissolved oxygen, light transparency, total phosphorus, total nitrogen, chlorophyll *a* (as a measure of phytoplankton biomass) and phytoplankton composition and density. The data showed 1) higher dissolved oxygen in the month of June and a reduced DO in the deeper water, 2) higher chlorophyll *a* concentration in the innermost sites, 3) higher total suspended load at mid-lagoon sites, and 4) higher total phosphorus concentrations in June and near the water inflow and outlet. This study upon completion will provide information on the biological, physical and chemical components of the water in the canals and probable strategies that will help to maintain a sustainable water quality. *Keywords: Water quality, Eutrophication, Phytoplankton.*

HANSEN, T.F., University of Wisconsin-Milwaukee School of Freshwater Sciences, 600 E. Greenfield Ave., Milwaukee, WI, 53207, USA. **A Highly Interactive Computational Fluid Dynamics Model.**

A highly interactive computational fluid dynamics (CFD) model is described. In its basic form, the model flow is visualized and projected on a wall. Users then place objects, or themselves, between the projector and the wall, and the shadows cast are detected by a digital video camera. The images of the shadows are then used to compute immersed boundaries in the path of the flow. The net effect is that the shadow appears as an object obstructing the flow, and the visualized flow reacts immediately to the changed boundaries. This allows the user to experiment with different arrangements and orientations of objects, or the user can simply stand in the flow field and reorient their limbs and posture, and see the results immediately reflected in the flow patterns. Early demonstrations to date have proven very popular with people of all ages and backgrounds, from very small children to seasoned professionals in a wide range of fields. The CFD model itself is based on the increasingly popular Lattice Boltzmann method (LBM). The model calculations are performed on a massively parallel Graphical Processing Unit (GPU) using vertex and fragment shaders coded in the GLSL language. Details of the system are described, including descriptions of visualization techniques employed. The model is verified by experiment, and results shown. *Keywords: Computer models, Education, Modeling, Technology, Water currents.*

HAPPEL, A.[1], PIKE, J.[2], CZESNY, S.J.[1], and RINCHARD, J.[2], [1]Illinois Natural History Survey, Prairie Research Institute, University of Illinois, 1816 S Oak Street, Champaign, IN, 61801, USA; [2]The College at Brockport - State University of New York, 350 New Campus Drive, Brockport, NY, 14420, USA. **Comparison of models that utilize fatty acids to provide estimates of diet composition.**

Diet composition data provide insights into how food webs respond to disturbances through changes in trophic interactions among constituents. Biochemical methods have recently gained popularity as alternative means to quantify diet compositions over multiple meals. Due to perceived power of included many variables, models tracing predator-prey relationships with fatty acid profiles have garnered much interest. Currently, a mixing model operating in a Bayesian framework (FASTAR), and a model that reduces statistical distances between predator and prey fatty acid profiles (QFASA) have been established. Herein we evaluate estimates provided by both models, using a novel controlled feeding experiment. Juvenile lake trout (*Salvelinus namaycush*) were fed diets that composed of various mixtures of bloodworm, daphnia, and shrimp for a period of 12 weeks. Diets included each prey in isolation, 50:50 mixtures of each pair of prey, and a diet composed of even mixtures of all three based on dry weights. Fatty acids of lake trout fed prey items in isolation were used as references, and each model was then challenged to estimate components of the mixed diets. Our results illustrate how fatty acids may be used to estimate diet components of wild individuals, providing data on long term foraging habits of wild individuals. *Keywords: Fish diets, Trout.*

HARDING, I.C., University of Minnesota Duluth, 1035 Kirby Dr., SSB 207, Duluth, MN, 55812, USA. **The Effect of *Bythotrephes longimanus* Invasion on Cisco Growth in Lake Superior.**

Bythotrephes longimanus is a predatory cladoceran zooplankton that invaded Lake Superior during the 1980s. *Bythotrephes longimanus* can compete for zooplankton resources with planktivorous fishes, are a low energy prey item, and are an additional trophic link that can decrease trophic transfer efficiency. These processes may disrupt energy flow to planktivorous fishes. Cisco (*Coregonus artedi*), have recently shown strong seasonal selection for *Bythotrephes longimanus* as a prey item in Lake Superior. I used bioenergetics models and growth histories to explore the effects of *Bythotrephes longimanus* invasion on Cisco growth in Lake Superior. Seasonal consumption of *Bythotrephes longimanus* may reduce growth of Cisco in Lake Superior. This work demonstrates the potential negative effects of species invasions and may be useful for Cisco recovery efforts in the lower Great Lakes. *Keywords: Bioenergetics, Invasive species, Lake Superior.*

HARRIS, L.E.[1] and ACKERMAN, J.D.[1], [1]University of Guelph, Guelph, ON, CANADA; [2]University of Guelph, Guelph, ON, CANADA. **The Effect of Velocity on the Carbon Isotope Fractionation of Aquatic Macrophytes.**

Smith and Walker (1980) proposed that the diffusive limitation of the boundary layer surrounding aquatic plants would limit carbon availability and result in less discrimination against ^{13}C. We investigated this mechanism in a laboratory experiment in which bicarbonate was the sole form of dissolved inorganic carbon present using *Vallisneria americana*, a bicarbonate user, and *Sagittaria subulata*, which is not known to use bicarbonate. *Vallisneria americana* was also examined in the Maitland River, Goderich, ON. The $\delta^{13}C$ signatures of *V. americana* in the laboratory and field became significantly more negative with increasing velocity whereas those of *S. subulata* became significantly more positive. The results for *V. americana* support Smith and Walker's mechanism, however those for *S. subulata* were opposite, which is likely due to differences in carbon uptake mechanisms between the two species. When analyzing $\delta^{13}C$ signatures of aquatic macrophytes, it is important to consider the fluid velocity, the photosynthetic mechanism and the type of carbon available. Understanding the effect of fluid velocity on carbon isotope fractionation is important for understanding trophic transfer in food webs and ecosystem dynamics. *Keywords: Vallisneria americana, Sagittaria subulata, Isotope studies, Velocity, Carbon, Food webs.*

HEBEBRAND, K.M. and BOSSENBROEK, J.M., University of Toledo, Toledo, OH, USA. **Potential Spread of Hydrilla (*Hydrilla verticillata*) to the Great Lakes Basin.**

Hydrilla (*Hydrilla verticillata*), an invasive aquatic plant, threatens to invade the Great Lakes Basin. Hydrilla creates dense webs that choke out native vegetation, reduces flow in canals, clogs water intakes, and interferes with navigation of watercraft. Recreational boating is a primary vector of spread for many aquatic invasive species, including hydrilla. The goal of this project is to predict the overland spread of hydrilla via recreational boating to the Great Lakes Basin using a gravity model. The model data requirements include: boater registrations, hydrilla occurrences, waterbody data, road networks, and watershed. The model was first parameterized based on the historical spread of hydrilla. Then, based on the 2015 distribution of hydrilla the model predicts where hydrilla will potentially spread over the next 10 years in the continental United States. Our results provide a relative ranking of watersheds most at risk to new introductions of hydrilla. The results of this model will contribute to a larger risk assessment and help prioritize management efforts.
Keywords: Modeling, Dispersal, Invasive species.

HEER, T., MANDRAK, N.E., and WELLS, M.G., University of Toronto Scarborough, 1265 Military Trail, Toronto, ON, M1C 1A4, CANADA. **Predicting Asian Carp Spawning in the Tributaries and Nearshore of the Canadian Great Lakes Basin.**

Due to the potential for an Asian carp invasion in the Great Lakes, there is a focus on identifying spawning in tributaries to the Canadian Great Lakes and methods to prevent successful spawning. By focusing on the hydrologic and temperature requirements of spawning, it is possible to determine whether Asian carp eggs will stay suspended in the water column long enough for the eggs to hatch. FluEgg is a three-dimensional Lagrangian model that recreates the turbulent flow conditions to test if carp eggs will stay suspended and includes a temperature-dependent hatching model to determine when the eggs will hatch (Garcia et al. 2013). To identify Canadian Great Lakes tributaries suitable for spawning, a subset of Lake Ontario and Lake Erie tributaries and their adjacent nearshore areaswill be sampled using an Acoustic Doppler current profiler and resulting data used in FluEgg to simulate the fate of the eggs. The results of the model will be used to identify potential spawning tributaries and evaluate possible management actions (e.g. barriers, altered flows) that could be used to prevent successful spawning. *Keywords: Mathematical models, Spawning, Great Lakes basin, Asian Carp, Invasive species.*

HELM, P.[1], ZIMMER, G.[1], STONES, M.[1], THIBEAU, J.[1], SIMS, A.[2], THORBURN, B.[1], and PAGE, W.[1], [1]Environmental Monitoring & Reporting Branch, Ontario Ministry of the Environment and Climate Change, 125 Resources Road, Toronto, ON, M9P 3V6, CANADA; [2]Laboratory Services Branch, Ontario Ministry of the Environment and Climate

Change, 125 Resources Road, Toronto, ON, M9P 3V6, CANADA. **Microplastics in and entering nearshore surface waters of the lower Great Lakes.**

Microplastic particles (MPPs) ranging 0.36 to 5 mm were sampled in surface waters via manta trawls and drift nets in nearshore Lake Ontario and Lake Erie, in urban impacted streams entering Lake Ontario, and in a wastewater treatment plant in 2014. The aim was to improve understanding of the primary types and sources of microplastics to the lakes to guide management considerations. MPP counts in lake waters ranged from 90,000 to 6,700,000 particles / sq. km, an order of magnitude higher than previous reports for Great Lakes waters, with geater amounts found near larger urban centers, including downstream of Detroit-Windsor in western Lake Erie, and in Humber Bay and Toronto Harbour along the Toronto waterfront. MPPs were described as fragments, beads, fiber, foam, film, or pre-production pellets. In most locations/samples, fragments were the dominant form of MPP, followed by fibers, with varying contributions from beads and foam. Although microbeads have been the focus of voluntary and legislative initiatives, characterizing their content remains a challenge as they often resemble fragments. In addition to fragmented litter and microbeads from personal care products, polystyrene foam from packaging / insulation, and shavings / cuttings from plastics operations are potential sources of microplastics to the Great Lakes. *Keywords: Microplastics, Lake Ontario, Pollution sources.*

<u>HENDRICKS, A.N.</u> and URBAN, N.R., Michigan Technological University, 1400 Townsend Drive, Houghton, MI, 49331, USA. **The Effects of Ice Cover on Fish Exposure to Methyl Mercury (MeHg).**

It remains unclear why methyl mercury (MeHg) concentrations in fish vary among the Great Lakes. In Michigan, fish in northern inland lakes exhibit higher concentrations than fish in the south. Fish from Lake Superior, the most northern Great Lake, also have highest MeHg concentrations. A potential factor contributing to the difference is ice cover. To test this hypothesis, a mathematical model was developed to evaluate effects of seasonality on mercury cycling. For simplicity, characteristics of a smaller lake were chosen for the model. Scenarios were developed to contrast a lake with ice cover to a lake without. These scenarios include seasonal changes in atmospheric deposition, lake mixing, solar radiation received in the water column, and air-to-water exchange of mercury. Scenarios were run in which only one of the mechanisms was altered at a time and then all were run together. The results suggest that ice cover increases MeHg in lakes, which is mainly a result of decreased sunlight penetration into the lake. Other scenarios showed that seasonal changes in lake mixing and atmospheric deposition decrease MeHg concentrations in lakes with seasonal ice cover, but these effects are smaller than that of seasonal variation in light penetration. *Keywords: Mercury, Modeling, Ice.*

HERBERT, M.E.[1], CALABRO, E.J.[2], CLARAMUNT, R.M.[3], GALAROWICZ, T.L.[2], CHADDERTON, W.L.[4], and TUCKER, A.J.[4], [1]The Nature Conservancy, 101 E. Grand River, Lansing, MI, 48906, USA; [2]Central Michigan University, Brooks Hall 217, Mount Pleasant, MI, 48859, USA; [3]Michigan Department of Natural Resources, Charlevoix Fisheries Research Station, 96 Grant Street, Charlevoix, MI, 49720, USA; [4]The Nature Conservancy, c/o Notre Dame Environmental Change Initiative, 1400 E. Angela Blvd., Unit #117, South Bend, IN, 46617, USA. **Restoration of critical Coregonid and Lake Trout reef spawning habitat in northern Lake Michigan.**

Great Lakes spawning reefs are critical features that have experienced impacts from habitat degradation and invasive species. A reef complex near Elk Rapids, Grand Traverse Bay, is the only known spawning reef complex used by Cisco (Coregonus artedi) in Lake Michigan; the reef is also used by Lake Trout (Salvelinus namaycush) and Lake Whitefish (Coregonus clupeaformis). Part of the reef complex has poor habitat quality, and subsequently egg deposition and survival are low. Baseline rates of invasive egg predators and egg deposition and survival for native reef spawners were quantified yearly from 2013-2015 on the degraded site and on a high quality portion of the reef complex (reference site). Physical characteristics were also quantified on the degraded and reference sites. In August 2015, we added 450 tons of cobble to improve the interstitial depth and habitat quality of the degraded site with the goals of reducing egg mortality and increasing egg deposition. We examined the initial effectiveness of the restoration through comparisons to the high-quality reference reef before and directly after restoration. We anticipate that determining the success of this restoration effort will require monitoring across multiple spawning seasons, as egg survivorship varies inter-annually as a function of storm events and predation.
Keywords: Lake trout, Cisco, Habitats, Reef, Restoration.

HEWITT, B.A. and SHARMA, S., York University, 4700 Keele Street, Toronto, ON, M3J 1P3, CANADA. **Effects of climate change on lake ice phenology and consequential ecosystem impacts on boreal lakes.**

Throughout the last century, Northern Hemisphere lake ice breakup has become earlier, freeze up has become later, and ice duration has become shorter with increasing rates over the last few decades. Our study examines how climate-induced changes on lake ice have influenced ecosystem structure of 7 inland boreal lakes in northern Wisconsin. Data were collected by the North Temperate Lake Long-Term Ecological Research Network between 1981-2015. Preliminary results suggest that on average, northern Wisconsin lakes froze 1.57

days per decade later (0.71- 2.5 days per decade), melted 1.48 days per decade earlier (0.91- 2 days per decade), and had a shorter ice cover season by 1.87 days per decade (0- 3 days per decade). Correspondingly, water temperatures have increased, and water clarity and productivity have changed. These shifts in lake ecosystems could alter ecosystem functionality in a changing world. *Keywords: Climate change, Ice, Ecosystems.*

HILLIS, E.L.[1], XENOPOULOS, M.A.[2], and HAFFNER, G.D.[1], [1]Great Lakes Institute for Environmental Research, Windsor, ON, CANADA; [2]Trent University, Peterborough, ON, CANADA. **Varying Responses of Primary Production and Chlorophyll *a* due to a Changing Lake Erie.**

'Re-eutrophication' in Lake Erie, mainly referring to the reappearance of harmful algal blooms (HABs) in the western basin, is a critical threat to both human and ecosystem health. Vollenweider et al. (1974) developed an empirical model relating primary production to chlorophyll *a* concentrations (chl *a*) in response to eutrophication in the Great Lakes in the 1960s. However, although chl *a* decreased in the west basin of Lake Erie in 2000 and 2001 compared to 1970, annual areal primary production remained similar to 1970 (Fitzpatrick et al. 2007), suggesting other factors may be interfering with this relationship. Expanding this study spatially, monthly (May-October) measurements of chl *a* and primary production were obtained in 2014 and 2015 from a nearshore and offshore site in all basins (west, central and east) of Lake Erie. Despite decreases in chl *a* in all basins compared to 1970, annual areal primary production has again remained similar, perhaps due to an increase in euphotic depth. In the west basin, there has been a general increase in carbon assimilation efficiency, perhaps partly due to dreissenids decreasing chl *a* more than primary production. Better understanding of the phytoplankton dynamics in Lake Erie are vital in order to determine the drivers of HABs. *Keywords: Harmful algal blooms, Lake Erie, Productivity.*

HINCHEY, E.K.[1], COLLINGSWORTH, P.D.[1], and BUNNELL, D.B.[2], [1]U.S. EPA Great Lakes National Program Office, 77 W. Jackson Blvd., Chicago, IL, 60604, USA; [2]Purdue University/IL-IN Sea Grant, 77. W. Jackson Blvd., Chicago, IL, 60604, USA; [3]USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105, USA. **Lake Michigan 2015 CSMI Field Year Overview.**

The binational Cooperative Science and Monitoring Initiative (CSMI) was initiated as the result of a need to coordinate agency science and monitoring in support of management of the Great Lakes ecosystem. The process includes enhanced monitoring and science field activities which are conducted in one lake per year, tied to the needs of the Lakewide Action and Management Plans (LAMPs). The 2015 Lake Michigan CSMI investigations by federal agencies and partners addressed key knowledge gaps in the distribution, abundance and movement of nutrients and biota (e.g., invertebrates and fish) across a nearshore to offshore gradient and status of the lower food web as a detection for ecological change. This presentation will provide an overview of the CSMI five-year cycle that involves science priorities development, field year planning, intensive field year science and monitoring, analysis and reporting to decision-makers. *Keywords: Monitoring, Lake Michigan, Lake management.*

HLEVCA, B.[1], WELLS, M.G.[1], ST. JOHN, M.[2], DOKA, S.E.[3], and COOKE, S.J.[4], [1]University of Toronto at Scarborough, 1265 Military Trail, Toronto, ON, M1C 1A4, CANADA; [2]Toronto and Region Conservation Authority, 101 Exchange Avenue, Vaughan, ON, L4K 5R6, CANADA; [3]Department of Fisheries and Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6, CANADA; [4]Department of Biology, Carleton University, 1125 Colonel By Drive, Ottawa, ON, K1S 5B6, CANADA. **Exchange Between Coastal Embayments and a Large Lake Primarily Driven by Water Level Oscillations.**

We show that in an embayment system connected to large lake, amplified water level oscillations can drive significant exchange that is reminiscent of tidal flows. We analyze water currents, water levels and temperatures in Toronto Harbour to determine the hydrodynamic characteristics and demonstrate that water level fluctuations with a period of one-hour drive most of the exchange flows with Lake Ontario. This exchange determined flows with water velocities as high as 0.8 m/s and residence times in the shallow embayments of order of days. The temperature differences between the shallow embayments and Lake Ontario during the stratified season were as high as 15°C. Strong lake upwelling events and wind-driven internal dynamics at diurnal and synoptic time scales can determine additional changes to the thermal regimes in the harbour. However, in contrast to the usual wisdom, we show that these processes do not result in the water exchange being dominated by baroclinic forcing. Our three-dimensional simulations indicate that barotropic processes are the dominant exchange and mixing mechanisms in the Toronto Harbour system of embayments. The model can be further used to determine the best geometry for restoration and new development work to help with creating the optimal habitat for targeted species. *Keywords: Hydrodynamic model, Seiches, Coastal wetlands, Fish habitat, Lake Ontario.*

HOFFMAN, D.K.[1], MCCARTHY, M.J.[1], DAVIS, T.W.[2], 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, 4840 S. State Road, Ann Arbor, MI, 48108, USA. **Water column ammonium dynamics affecting harmful cyanobacterial blooms in Lake Erie.**

Cyanobacterial harmful algal blooms (HABs) in western Lake Erie are driven largely by agricultural nitrogen (N) and phosphorus from the Maumee River watershed. Cyanobacterial dominance and HAB development may depend on ammonium (NH4+) availability, and increased NH4+ has been linked to increased toxin production. *Microcystis*, the dominant toxic cyanobacteria, cannot fix atmospheric N2; thus, it must compete for NH4+. Understanding the factors governing N cycling and NH4+ availability is therefore crucial for identifying conditions that drive HABs. To quantify these dynamics, three sites along a northeast transect from the Maumee River mouth across the western basin were sampled monthly from June-September 2015. Stable isotope tracers (15N) were used to quantify rates of NH4+ regeneration and potential uptake, ammonia oxidation to nitrite, and total nitrification. Ammonia oxidation rates were comparable to those in Lake Taihu and much greater than those found in oligotrophic high-altitude lakes. However, these rates were lower than total NH4+ uptake rates, indicating that ammonia oxidation is not the dominant uptake pathway. Total NH4+ uptake and regeneration rates were similar, suggesting that internal recycling of NH4+ may support continued stimulation and maintenance of HABs.
Keywords: Lake Erie, Harmful algal blooms, Nutrients.

HOFFMAN, J.[1], TREBITZ, A.[1], HOLLENHORST, T.[1], COTTER, A.[1], SIERSZEN, M.[1], SCHAROLD, J.[1], BOLGRIEN, D.[1], MILLER, S.[1], OPSETH, A.[2], BARTSCH, W.[1], LIETZ, J.[1], and MOHN, L.[1], [1]US EPA Mid-Continent Ecology Division, 6201 Congdon Blvd., Duluth, MN, 55804, USA; [2]Badger Technical Services, 6201 Congdon Blvd., Duluth, MN, 55804, USA. **Stable Isotope Differences Among the Lake Michigan 2015 CSMI Transects.**

During the Lake Michigan 2015 Cooperative Science and Monitoring Initiative (CSMI), eight transects situated near tributaries that present a gradient of phosphorus loads were sampled from nearshore to offshore during May, July, and September. Our objective was to evaluate associated patterns in carbon and nitrogen stable isotope ratios of particulates and bulk zooplankton samples. Each transect was comprised of three stations arranged nearshore to offshore (18-110 m depth). At each station, samples for stable isotope analysis were obtained from both the epilimnion and the metalimnion or deep chlorophyll layer. We found a substantial isotopic gradient in zooplankton. Zooplankton were relatively 13C-enriched and 15N-depleted in epilimnetic waters sampled in July and September, though a tributary-associated difference was not detected. In contrast, zooplankton sampled in May and in the metalimnion were relatively 13C-depleted and 15N-enriched. These isotopic patterns are opposite that associated with differences in trophic level among zooplankton, indicating that systematic differences in biogeochemistry or food web inputs are likely the cause. Our results demonstrate that both seasonal and depth-specific differences in zooplankton must be recognized for correct stable isotope-based pelagic food web interpretation. *Keywords: Lake Michigan, Stable isotopes, Water quality, Nutrients.*

HOFFMAN, M.J. and HITTINGER, E., Rochester Institute of Technology, 85 Lomb Memorial Dr., Rochester, NY, 14623, USA. **Modeling Plastic Input and Transport in the Great Lakes.**

In the last few years, microplastics have been recognized as a serious chemical of concern within the Great Lakes. Open water sampling campaigns and beach cleanups have established the presence of microplastics, but are only available at certain times and in certain places. We present results from an effort to estimate plastic input from the shorelines of the Great Lakes and model the three-dimensional transport of this debris through the Lakes over a multiyear period. Census data from both the United States and Canada are used to estimate plastic influx and model output from NOAA's Great Lakes Coastal Forecast System (GLCFS) is used to compute the transport of the plastic in the Lakes. This project aims to establish estimates of microplastic influx into and spatiotemporal maps of microplastic abundance in the Great Lakes. *Keywords: Modeling, Microplastics, Pollution load.*

HOFFMAN, M.J. and CABONE, D., Rochester Institute of Technology, 85 Lomb Memorial Dr., Rochester, NY, 14623, USA. **Comparing Methods for Finding Lagrangian Coherent Structures for the 2011 Lake Erie Algal Bloom.**

Lagrangian Coherent Structures (LCS) are persistent local structures in a time-varying flow and identifying LCS at a certain time cam provide a map of both pathways for and barriers to transport. LCS have been used in many marine applications, including tracking oil spills and predicting the spread of algal blooms. There are many methods for computing LCS and here we look at two methods for computing LCS--a variational method of Onu et al. (2015) and the M-function of Macho et al. (2013)--and compare their performance in explaining transport for the 2011 algal bloom in Lake Erie. Results from the methods are evaluated by comparing to MODIS satellite images and to the modeling study of Michalak et al. (2013). Computational complexity of the two methods is also considered. The LCS in both methods are computed using velocity fields from NOAA's Great Lakes Operational Forecast System (GLOFS) to propagate particles across the surface of Lake Erie. *Keywords: Comparison studies, Harmful algal blooms, Modeling.*

HOFFMANN, J.M.[1], MUIR., A.M.[2], VINSON, M.R.[3], KRUEGER, C.C.[4], BRONTE, C.R.[5], LOSETO, L.L.[6], HANSEN, M.J.[7], SITAR, S.P.[8], and SWANSON, H.K.[1], [1]Department of

Biology, University of Waterloo, Waterloo, ON, CANADA; [2]Great Lakes Fishery Commission, Ann Arbor, MI, USA; [3]USGS Great Lakes Science Center, Ashland, MI, USA; [4]Michigan State University, East Lansing, MI, USA; [5]US Fish and Wildlife Service, New Franken, WI, USA; [6]Fisheries and Oceans Canada, Winnipeg, MB, CANADA; [7]USGS Great Lakes Science Center, Millersburg, MI, USA; [8]Michigan Department of Natural Resources, Marquette, MI, USA. **Quantifying Trophic Position and Niche Overlap among Morphotypes of Lake Trout in Lake Superior.**

Four morphotypes of Lake Trout (*Salvelinus namaycush*) have been identified in Lake Superior: lean, siscowet, humper, and redfin. Humper, redfin, and siscowet all inhabit deep waters >80m, but little is known about inter-morph interactions for prey resources. In this study, we are characterizing the diet and trophic niche of Lake Trout morphs using stomach content, stable isotope, and fatty acid data. Preliminary stomach content results indicate that *Mysis* was the most important prey item for all four morphotypes at the time they were captured; stable isotope and fatty acid data will be used to indicate longer-term importance of diet items. Stomach, stable isotope, and fatty acid data are also being used in a new statistical model to quantify trophic niches of each Lake Trout morphotype, and to estimate the probability of niche overlap between morphotypes.

Results from our study provide insight into resource partitioning among morphotypes of Lake Trout in Lake Superior. This has application in informing stock restoration efforts in the Great Lakes. By understanding trophic interactions among morphotypes and morphotype-specific use of prey resources, policy makers will have the ability to make more informed decisions about Lake Trout restoration efforts. *Keywords: Lake trout, Fatty acids, Stable isotopes, Niches.*

HOLBROOK, C.M.[1], NATE, N.A.[2], and KRUEGER, C.C.[3], [1]USGS Hammond Bay Biological Station, 11188 Ray Rd., Millersburg, MI, 49759, USA; [2]Michigan State University, Center for Systems Integration and Sustainability, 11188 Ray Rd., Millersburg, MI, 49759, USA; [3]Michigan State University, Center for Systems Integration and Sustainability, 1405 South Harrison Road, 115 Manly Miles Building, East Lansin, MI, 48823, USA. **The Great Lakes Acoustic Telemetry Observation System: First five years.**

The Great Lakes Acoustic Telemetry Observation System (GLATOS; www.data.glos.us/glatos) is a network of researchers using acoustic telemetry to track fish in the Laurentian Great Lakes. During the first five years (2010-2015) more than 33 acoustic telemetry projects were conducted by 21 agencies and universities in the U.S. and Canada. More than 4900 fish of 33 species were tagged and released and receivers were maintained at over 1500 locations. The GLATOS website and annual coordination meetings have fostered partnerships and project discovery. The GLATOS database has extended the effective geographic range of individual telemetry studies by providing basin-wide access to fish detection data across projects. Continued enhancement and development of GLATOS will support and inform local, regional, and international fisheries management decision-making and policy development on issues such as native fish restoration, habitat protection, improving recreational fishing, and improving assessment and control of invasive species. GLATOS is administered by the Great Lakes Fishery Commission, in partnership with the Great Lakes Observing System, the U.S. Geological Survey, Michigan State University, and the Ocean Tracking Network, and supported by the Great Lakes Restoration Initiative. *Keywords: Fisheries, Telemetry, Mitigation, Fish management.*

HOLDA, T.J.[1], BOWEN, K.L.[2], RUDSTAM, L.G.[1], WEIDEL, B.C.[3], HOLDEN, J.P.[4], CONNERTON, M.J.[5], and WATKINS, J.M.[1], [1]Cornell Biological Field Station, 900 Shackelton Point Rd, Bridgeport, NY, 13030, USA; [2]Fisheries and Oceans Canada, 867 Lakeshore Rd, Burlington, ON, L7R 4A6, CANADA; [3]United States Geological Survey, 17 Lake St, Oswego, NY, 13126, USA; [4]Ministry of Natural Resources and Forestry, 41 Hatchery Ln, Picton, ON, K0K 2T0, CANADA; [5]New York State Department of Environmental Conservation, 541 East Broadway, Cape Vincent, NY, 13618, USA. **State of *Mysis diluviana* in Lake Ontario in 2013: Context over time and space.**

Mysis diluviana are important members of the offshore community in the Great Lakes, perhaps especially Lake Ontario. They are an abundant food resource for a variety of fishes, significant competitors with fish and zooplankton for food resources, and a biological vehicle for linking pelagic and benthic systems. During 2013, 277 net samples were collected for mysids, along with about 130 hours of night-time acoustic sampling. We report abundance, biomass, demographics, growth, fecundity, productivity, spatial distribution, and seasonal trends. Density of mysids ranged from 71-130 per m2 throughout the 2013 field season, being lowest in October. Biomass ranged from 0.26 to 0.42 g·m-2 dry-weight throughout the year for both acoustic and net-based estimates. Two cohorts (YOY and Y1) were present most of the year. Growth rates were 1.34 and 0.72 mm·month-1 for YOY and Y1. We compare our findings to previous studies in Lake Ontario, and concurrent studies in Lakes Superior, Michigan, and Huron. *Keywords: Lake Ontario, Mysids, Productivity, Spatial distribution.*

HOLETON, C.[1], HOWELL, E.T.[1], CHIANDET, A.S.[2], SHERMAN, R.K.[2], MCPHAIL, A.[2], HUGHSON, R.[2], and BENOIT, N.[1], [1]Ontario Ministry of Environment and Climate Change, 125 Resources rd., Toronto, ON, M9P3V6, CANADA; [2]Severn Sound Environmental Association, 67 Fourth st., Midland, ON, L4R3S9, CANADA. **Testing Influences of Driver Gradients on the Nearshore Nutrient Regime in Eastern Georgian Bay.**

The majority of Georgian Bay has not had the same degree of monitoring attention as other areas on the Great Lakes for many reasons, one of which is its comparatively pristine waters. However, as multiple stressors such as climate change, invasive species, human development and low phosphorus inputs from the Precambrian Shield act to shape the nearshore zone, the need to characterize this valuable ecosystem and gain a better understanding of the drivers of variability in the nutrient regime has become apparent. A study was undertaken using existing datasets to characterize nearshore water quality and to create metrics summarizing gradients in tributary inputs, exposure to mixing with offshore water, stratification patterns and coastal development over varying spatial scales. To test the hypothesis that gradients in watershed and coastline characteristics influence the nutrient regime, data were used from sites in the Severn Sound area, as well as embayments sites up the coast that were selected to span gradients in several metrics such as exposure and tributary influence. The metrics explained differing amounts of variability in nutrient regime. The approach taken in this study will provide useful examples of using metric gradients to design monitoring programs that can adequately capture variability in response variables. *Keywords: Nutrients, Spatial analysis, Monitoring, Nearshore, Georgian Bay, Variability.*

HOLLENHORST, T.[1], LAUNSPACH, J.J.[2], FIORENTINO, L.A.[3], SAMUELSON, A.L.[1], HOFFMAN, J.[1], and BROWN, T.N.[1], [1]US EPA Mid-Continent Ecology Division, 6201 Congdon Blvd., Duluth, MN, 55804, USA; [2]SRA International Inc, 6201 Congdon Blvd, Duluth, MN, 55804, USA; [3]Large Lakes Observatory University of Minnesota, Duluth, 2205 E 5th St,, Duluth, MN, 55812, USA. **Sub Aquatic 3D Visualization and Temporal Analysis Utilizing ArcGIS Online, Story Maps and 3D Apps.**

We used 3D Visualization tools to illustrate some complex water quality data we've been collecting in the Great Lakes. These data include continuous tow data collected from our research vessel the Lake Explorer II, and continuous water quality data collected from an autonomous underwater robot or Slocum Glider. Both sensors move up and down through the water column, so the data needs to be represented both vertically and horizontally through time. The data metrics include conductivity, temperature, depth, fluorescence, nitrate, and plankton abundance. Working with story maps and 3D visualization tools allow us to present complex spatial/temporal data sets to the public via an easy to use intuitive interface. As we automate this process we'll be able process and present these types of data almost as soon as they are collected. *Keywords: Water quality, Data visualization, Data storage and retrieval, GIS.*

HORNSBY, R.L. and TUFTS, B.L., Queen's University, 116 Barrie St., Kingston ON, ON, K7L 3N6, CANADA. **Movements of Black Bass After Tournament Displacement in the Bay of Quinte and Eastern Lake Ontario.**

Black Bass are an economically important species for catch and release tournaments in North America. The Bay of Quinte (BOQ) and Eastern Basin of Lake Ontario (ELO) are subject to heavy angling pressure, with 17 multi day tournaments occurring over 3-months. This study sought to examine the effects of long distance displacement (15-100 km) on black bass in the BOQ and ELO. A network of 43 stationary acoustic receivers (69 kHz VR2W, Vemco) was deployed in June 2015 in the BOQ and at Main Duck Island. 30 Largemouth Bass (*Micropterus salmoides*) and 30 Smallmouth Bass (*M. dolomieu*), 12 controls and 18 displaced of each species, were surgically implanted with acoustic transmitters (V14-1H/V14-4H, Vemco). 3 months following release, 1 (5%) Largemouth Bass and 1 (5%) Smallmouth Bass had returned to near their site of capture (10 km and 95 km respectively). Overall Smallmouth exhibited more searching behaviour than Largemouth; 2 made long distance movements, 24 km and 95 km. Only 1 displaced Largemouth travelled 5 km further than the control Largemouth individuals. Results from this study will aid in keeping catch and release tournaments sustainable. *Keywords: Micropterus, Bay of Quinte, Acoustics.*

HOSSAIN, M.[1], STEWART, T.J.[2], ARHONDITSIS, G.B.[3], MINNS, C.K.[4], and KOOPS, M.[1], [1]Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries and Oceans Canada, 867 Lakeshore Rd, Burlington, ON, L7S 1A1, CANADA; [2]Ontario Ministry of Natural Resources and Forestry, 41 Hatchery Lane, Picton, ON, KOK 2T0, CANADA; [3]Department of Physical & Environmental Sciences, University of Toronto, Toronto, ON, M1C 1A4, CANADA; [4]Department of Ecology and Evolutionary Biology, University of Toronto, Toronto, ON, M5S 3B2, CANADA. **Assessing uncertainty in a Lake Ontario Ecopath model: An application of linear inverse model.**

ECOPATH with ECOSIM (EwE) is a widely used mass-balance modeling approach that synthesizes biomass and biological rates to identify energy pathways and knowledge gaps of the ecosystem. However, EwE lacks clear objective criteria to determine the best from a large number of potential solutions to the under-determined mass-balance problem. In contrast, linear inverse model (LIM) is increasingly used to solve similar mass-balance problems using an objective least-squares criterion that can effectively evaluate the EwE estimates by objectively reconstructing the unknown flows using upper and lower limits to the input parameters. In this study, we translated a published Lake Ontario EwE model into a LIM model and illustrate how it can complement the EwE model and quantify uncertainty in both flows and ecosystem indices. Preliminary results demonstrate that flow rates estimated from the LIM model can completely mimic the EwE model. We modify the constraints of the EwE model (e.g. impose general physiological constraints such as assimilation efficiency and growth rate instead of production or consumption rates) for all compartments and explore some advantages of LIM. This allows us to assess associated uncertainties of the flows and to make recommendations regarding future applications of LIM to Great Lakes research and management. *Keywords: Lake Ontario, Mass balance, Ecosystem modeling.*

HOUGHTON, C.J.[1], MORATZ, C.C.[1], FORSYTHE, P.S.[1], LAMBERTI, G.A.[2], UZARSKI, D.G.[3], and BERG, M.B.[4], [1]University of Wisconsin-Green Bay, 2420 Nicolet Dr, Green Bay, WI, 54311, USA; [2]University of Notre Dame, 290D Galvin Life Science Center, Notre Dame, IN, 46556, USA; [3]Central Michigan University, 1200 S. Franklin St., Mount Pleasant, MI, 48859, USA; [4]Loyola University Chicago, 1032 W. Sheridan Rd, Chicago, IL, 60660, USA. **Relative use of wetland and nearshore habitats by sportfishes of Green Bay.**

The sportfish community of Green Bay is mostly made up of transient nearshore species. These sportfish are known to make feeding excursions into tributaries and associated wetlands and trophically link the two habitats. To assess the relative importance of wetland derived energy to sportfish (yellow perch, walleye, largemouth bass, smallmouth bass, and northern pike) we collected fish from nearshore and wetland habitats at seven locations (Rapid River, Michigan to Dead Horse Bay, Wisconsin) in 2014 and 2015. Fish tissue stable isotopes and otolith microchemistry were used to determine relative energy contribution and habitat utilization of Green Bay sportfish. *Keywords: Food chains, Otolith microchemistry, Wetlands, Stable isotopes.*

HOWELL, E.T., Ontario Ministry of Environment and Climate Change, 125 Resources Road, Toronto, ON, M9P 3V6, CANADA. **Nearbed Phosphorus, Cladophora and Dreissenid Mussels Over a Productivity Gradient in Lake Ontario.**

The green algae *Cladophora* proliferates on the north shore of Lake Ontario despite oligotrophic conditions in the lake. The light-limited depth of optimal growth overlaps with zones of nutrient enrichment in the nearshore. Efflux of nutrients from the dreissenid-covered lakebed may also contribute to *Cladophora* growth. Studies in 2012 and 2013 examined *Cladophora* biomass and tissues phosphorus, dissolved nutrients and dreissenid density over an east to west nearshore productivity gradient on the north shore. Nutrient sampling at 10 cm above lakebed indicated higher dissolved phosphorus over the more westward and developed shoreline suggesting anthropogenic enrichment. Tissue phosphorus was lowest at the most eastward study area indicating stronger phosphorus growth limitation then elsewhere. However, *Cladophora* was abundant at all areas with biomass seemingly inversely correlated with the productivity gradient. Biomass of *Cladophora* was positively correlated with quagga mussel numbers at deeper sites but not at shallower depths with higher algae biomass. Understanding the roles of area-specific external, within basin and internal nutrient supply on *Cladophora* growth is critical for setting algae abatement priorities. *Keywords: Lake Ontario, Nutrients, Cladophora.*

HOWELL, G.M. and ROONEY, R.C., University of Waterloo, Waterloo, ON, N2L3G1, CANADA. **An Investigation of Invasive *Phragmites* Restoration Treatments in a Lake Erie Coastal Marsh.**

Invasive *Phragmites australis* is a wetland perennial grass native to Europe. In North America this species threatens wetland biodiversity by monopolizing resources and decreasing floral diversity (Meyerson et al., 2000). Herbicide application and mechanical removal are common *Phragmites* control treatments, however little is known about how these treatments affect the regrowth of resident species following *Phragmites* removal (Hazelton et al., 2014). In 2015 we conducted a plot experiment to test *Phragmites* restoration strategies in a Long Point coastal marsh on Lake Erie. We tested five options: herbicide alone, herbicide and cutting litter, herbicide and flattening litter, cutting alone and flattening litter alone. Herbicide treatments were significantly more effective at reducing *Phragmites* stem density and percent cover. With the exception of the spraying and cutting treatment, however, treatments involving herbicide application significantly reduced the regrowth of resident species in terms of stem density and percent cover. Herbicide combined with cutting appears to be the best treatment in terms of eradicating *Phragmites* while encouraging the regrowth of native marsh vegetation. An examination of the long term response of resident species to treatments will begin in 2016. *Keywords: Glyphosate, Restoration, Phragmites australis, Wetlands.*

HRABIK, T.R.[1] and ROTH, B.M.[2], [1]University of Minnesota, Duluth Campus, 1035 Kirby Drive, Duluth, MN, 55812, USA; [2]Michigan State University, 480 Wilson Rd., East Lansing, MI, 48824, USA. **The Role of Demersal prey in Mediating Diel Vertical Movement by Siscowet in Lake Superior.**

A substantial portion of siscowet (Salvelinus namaycush siscowet) in Lake Superior undergo diel vertical migration (DVM). This migration behavior is linked specifically to following vertically migrating prey species including kiyi (Coregonus kiyi) and other coregonines. However, a portion of the siscowet population, which varies seasonally and among years, fails to move vertically on any given day. We conducted individual based model scenarios to explore the possible mechanisms underlying foregoing migration by some individuals in the population. To test the hypothesis that demersal prey encounter may influence the decision to migrate, we systematically varied demersal prey abundance and held vertically moving prey (coregonine) abundance constant. In model scenarios, growth was maximized by following prey only when siscowet were unable to obtain high rations from consuming demersal prey (e.g. sculpins) during the day. When demersal prey availability is high, the cost of migration exceeds the benefit of DVM behaviors. Our results suggest that individuals make the decision to undergo DVM based on foraging profitability, which can exhibit threshold-like behavior from subtle changes in prey abundance. *Keywords: Fish behavior, Fish populations, Lake Superior.*

HUBBARD, L.E.[1], ROBERTSON, D.M.[1], LORENZ, D.L.[2], and DECICCO, L.[3], [1]U.S. Geological Survey, Wisconsin Water Science Center, 8505 Research Way, Middleton, WI, 53562, USA; [2]U.S. Geological Survey, Minnesota Water Science Center, 21280 Woodale Drive, Mounds View, MN, 55112, USA; [3]U.S. Geological Survey, Office of Water Information, 8505 Research Way, Middleton, WI, 53562, USA. **Improved Nutrient and Sediment Loading estimated using Continuous Surrogate Regression Techniques.**

Nutrient and sediment loading in streams has been quantified using various statistical techniques, usually calibrated using continuous streamflow and limited discrete water-quality samples. To improve these estimates without collecting more frequent water samples, a new load technique was developed that extends the regression approach to include continuously measured surrogate variables, such as turbidity. This continuous surrogate regression approach was used to estimate nutrient and sediment loading from 30 Great Lakes tributaries. For each constituent (total and dissolved phosphorus and nitrogen and suspended sediment), the same form of regression model was used for all tributaries; the final chosen variables provided the best overall statistical fit for the majority of the sites. Continuous loads and confidence intervals were calculated using the U.S. Geological Survey LOADEST program modified to include continuous surrogate variables. Based on various measures describing model fit, the surrogate regression approach improved load estimates for all constituents compared to regressions not including surrogates; however, largest improvements were for constituents related to particulates in the water column. This new approach provides improved long-term load estimation and continuous estimates of short-term, sub-daily loading. *Keywords: Pollution load, Sediment load, Nutrients.*

HUNTER, T.S.[1], SLAWECKI, T.[2], and SMITH, J.P.[3], [1]NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Rd., Ann Arbor, MI, 48108-9719, USA; [2]Limnotech, 501 Avis Drive, Ann Arbor, MI, 48108, USA; [3]Cooperative Institute for Limnology and Ecosystems Research, G110 Dana Building 440 Church Street, Ann Arbor, MI, 48109-1041,

USA. **"MVC" environmental informatics software foundation for relationship-based collaborative science.**

Products of software engineering and computer science often follow a Model-View-Controller (MVC) architectural pattern. In an environmental informatics context, MVC can serve as a conceptual framework for task delegation and help foster productive relationship-based science collaboratives, bringing policy makers and other stakeholders to the same table as scientists and software engineers. This talk will go over the MVC architecture, describe where stakeholders fit in, and how a few projects around the Great Lakes follow this pattern. Projects that will be discussed include The Great Lakes Dashboard and the Advanced Hydrologic Prediction System from NOAA-GLERL. *Keywords: Ecosystem modeling, Informatics, Mathematical models, Software engineering, Modeling, Design.*

HUTTON, M.A.[1], COLLINGSWORTH, P.D.[2], GUFFEY, S.C.[1], RUTHERFORD, E.S.[3], ZISCHKE, M.T.[1], and HÖÖK, T.O.[1], [1]Purdue University, 195 Marstellar St., West Lafayette, In, 47907, USA; [2]Indiana-Illinois SeaGrant, 195 Marstellar St., West Lafayette, In, 47907, USA; [3]NOAA-Great Lakes Environmental Research Laboratory, 4840 S. State Rd., Ann Arbor, MI, 48109, USA. **Assessing a Secondary Consumer through Space and Time: The Story of L. Michigan *Bythotrephes*.**

Lake Michigan has undergone numerous ecosystem changes. Various studies have highlighted ecosystem changes in offshore locations, and, more recently, studies have identified substantial changes in nearshore conditions. These changes include increasing concentrations of primary producers and a higher reliance on nearshore resources by tertiary consumers. However, these changes are not ubiquitous throughout the lake. Also, responses of secondary consumers to recent ecosystem changes are less studied. We utilized the 2015 Cooperative Science and Monitoring Initiative to obtain spatially and temporally stratified samples of *Bythotrephes longimanus* - a representative secondary consumer. Nine transects were sampled throughout Lake Michigan along a nearshore (~15m) to offshore (~105m) gradient. From these samples, we assessed the density, condition (via RNA:DNA ratios, fecundity, and length-at-instar) and diet patterns (via fatty acid signatures). Preliminary analyses indicate significant differences in the condition and diet on broad spatial scales (between eastern and western shores), though differences across fine spatial scales (nearshore to offshore) were less pronounced. This study provides important information on the performance of a key species which may have implications for other secondary consumer. *Keywords: Zooplankton, Nearshore, Lake Michigan, Condition.*

I

IGRAS, J.D.[1], CREED, I.F.[2], LAURENT, K.L.[2], and CORMIER, R.[3], [1]Western University Social Science, 1151 Richmond St, London, On, N6A3K7, CANADA; [2]Western University Science, 1151 Richmond St, London, On, N6A3K7, CANADA; [3]Institute for Coastal Research, Max-Planck-Straße 1, Geesthacht, 21502, GERMANY. **Quantifying agricultural best management practices in Ontario`s Grand River Watershed.**

Eutrophication and nuisance algae in the Laurentian Great Lakes has re-emerged as a potential threat to valued ecosystem services. Monitoring and research suggests that management is effective at reducing total phosphorus (TP) loads below policy objectives, however, it fails to prevent eutrophication and related impacts to be avoided under the Great Lakes Water Quality Agreement (GLWQA; 2012). We quantified the TP and soluble reactive phosphorus (SRP) reduction performance of different agricultural best management practices (BMPs) and implemented the data in Bayesian network meta-models. We applied the meta-model to Ontario's Grand River watershed to calculate the probability of failing to achieve a 40% reduction in TP and SRP load to Lake Erie's eastern basin. Our analysis uncovered differential implications for TP and SRP reductions and sometimes, antagonistic effects were observed. We conclude that BMP performance for TP reduction, and of greater concern; SRP reduction, is not adequate to achieve a 40% load reduction in most years. Of particular concern is the probability of increased SRP load from different BMPs. Our results suggest the need to expand management to target SRP reduction; conventional targeting of TP alone has increased the probability of SRP load to Lake Erie. *Keywords: Phosphorus, Agriculture, Management, Risk, Water quality, Best management practice.*

ILAMPOORANAN, I.[1], VAN METER, K.J.[2], and BASU, N.B.[1], [1]Department of Civil and Environmental Engineering, University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L 3G1, CANADA; [2]Department of Earth and Environmental Sciences, University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L 3G1, CANADA. **Modeling Nutrient Legacies and Time Lags in Agricultural Watersheds: A Midwestern Case Study.**

Massive land use changes and fertilizer inputs to increase food production have altered the global N cycle and impaired water quality thereby affecting human and ecosystem health. Various best management practices (BMPs) implemented to mitigate these impacts often do not yield the desired benefits. We hypothesize that such lack in response arises due to substantial time lags between the implementation of BMPs and improvements in water quality. To understand the accumulation and depletion of legacy stores in agricultural landscapes, we, (i) quantify the contribution of legacy N storage to riverine flux using a regression-based approach through historical reconstruction of N inputs and outputs from 1949 to present; (ii) develop a framework to couple a distributed watershed model (SWAT) with the travel time distribution approach to model N accumulation and biogeochemical and hydrologic time lags in the Iowa Cedar Watershed (1949 - 2014). This framework will thus provide a better understanding on N sources, stores, fluxes as well as the time lags associated with climate and land use / management practices to achieve desirable water quality benefits. Although the study is specific to the Midwestern US, the methods developed are easily translatable to the Great Lakes Watersheds. *Keywords: Mass balance, Nitrogen Legacy, Modeling, Time lags.*

IRAMBONA, C.[1], MUSIC, B.[2], NADEAU, D.[3], and FRIGON, A.[2], [1]Polytechnique Montreal, Department of Civil, Geological and Mining Engineering, Montreal, QC, H3T 1J4, CANADA; [2]Ouranos - Consortium on regional climatology and adaptation to climate change, 550 Sherbrooke W., Montreal, QC, H3A 1B9, CANADA; [3]Université Laval, Departement of Civil and Water Engineering, Quebec City, QC, H9X 3V9, CANADA. **Moisture recycling over the Laurentian Great Lakes as simulated by the CRCM5.**

Evaluating moisture recycling over the Great Lakes Basin provides useful information on the importance of land-lake-atmosphere interactions in the regional hydrological cycle. Higher moisture recycling suggests stronger coupling between the atmosphere and the underlying surface. Moisture recycling can be quantified by calculating the so-called precipitation recycling ratio, defined as the contribution of evaporation in a delimited region to precipitation in that same region. This study assesses the ability of the Canadian Regional Climate Model, Version 5 (CRCM5) to simulate the Great Lakes Basin hydrology and to evaluate potential effects of global warming on precipitation recycling over the region, now that the CRCM5 is fully coupled with a 1D lake model (Flake). The analysis is based on the Brubaker 2D recycling model and other methods will also be explored. *Keywords: Great Lakes basin, Hydrologic cycle, Climate change.*

IRVINE, C. and MACRAE, M.L., Dept. of Geography and Environmental Management, University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L 3G1, CANADA. **Seasonal phosphorus dynamics of Hopewell Creek and its tributaries in a multiple land-use watershed.**

The transport and speciation of phosphorus (P) to receiving water bodies has been widely studied at the field scale to better understand the complex transport dynamics of P to surface water bodies. To evaluate the temporal dynamics of seasonality and storm response related to P export via streams, a larger watershed scale approach was used to monitor and collect stream water samples within the Hopewell Creek watershed which serves as a tributary to the Grand River. Sample collection sites were established with one located at the outlet of the watershed, two which have predominately agricultural land use and one with a forested headwater contributing area. Water samples were collected at high-frequency during storm flow events over the course of one year throughout the watershed. Event response magnitude and timing varied spatially between the headwaters and watershed outlet. Seasonally, the highest P concentrations were exported during the snowmelt period. At this time, flow-weighted mean P concentrations and loads were greater in the area dominated by livestock in comparison to other sites within the watershed. Spatial and temporal patterns in P loss throughout the watershed will be discussed. *Keywords: Phosphorus, Grand River, Tributaries.*

IVANOVA, N.V.[1], DAVIS, T.W.[2], BULLERJAHN, G.S.[3], WATSON, C.[4], and WATSON, S.B.[4], [1]Centre for Biodivesity Genomics, Biodiversity Institute of Ontario, University of Guelph, 50 Stone Road East, Guelph, ON, N1G 2W1, CANADA; [2]NOAA - Great Lakes Environmental Research Laboratory, 4840 S. State Road, Ann Arbor, MI, 48108-9719, USA; [3]Bowling Green State University, Life Sciences 516, Bowling Green, OH, 43403, USA; [4]Watershed Hydrology and Ecology Research Division, Water Science and Technology, Environment Canada, 867 Lakeshore Road, Burlington, ON, L7S 1A1, CANADA. **Rapid Assessment of Algal and Bacterial Community Composition and Harmful Blooms Using DNA Barcoding.**

Our ability to monitor and remediate impaired waterbodies is severely challenged by their vast geographical scale. An example is Lake Erie, with a dramatic east-west gradient in water quality and plankton biodiversity as a result of high nutrient inputs from multiple shoreline sources, many unmonitored. Using this lake, we are applying DNA barcoding and Next Generation Sequencing (NGS) to develop a rapid assessment toolset for three important indicators of ecosystem health: toxigenic bloom-forming cyanobacteria; impaired planktonic biodiversity; and bacterial 'fingerprint' tracers of different shoreline inputs. The project has two major goals: 1) build a reference BOLD database for algal and cyanobacterial 16S rRNA, using isolates from the Great Lakes and other regions; 2) use this to analyze environmental samples to simultaneously detect cyanobacteria, eukaryotic algae and heterotrophic bacteria using targeted NGS with specific and universal 16S primers. To overcome NGS method constraints, such as PCR bias, we are first testing mock communities generated from known cyanobacterial and eukaryotic algal cultures. The project outcome will also enable detection of bacterial indicator species typically associated with different nutrient sources (wetlands, wastewater, agricultural runoff), and thus aid in their source tracking. *Keywords: Harmful algal blooms, DNA barcoding, Lake Erie, Next-Generation Sequencing, Indicators, 16S.*

IVES, J.T.[1], MCCANN, K.S.[2], MCMEANS, B.C.[2], BUNNELL, D.B.[3], JOHNSON, T.B.[4], FISK, A.T.[5], and MUIR, A.M.[1], [1]Great Lakes Fishery Commission, 2100 Commonwealth Blvd., Suite 100, Ann Arbor, MI, 48105, USA; [2]Department of Integrative Biology, University of Guelph, Guelph, ON, CANADA; [3]Great Lakes Science Center, United States Geological Survey, Ann Arbor, MI, USA; [4]Glenora Fisheries Station, Ontario Ministry of Natural Resources and Forestry, Picton, ON, CANADA; [5]Great Lakes Institute for Environmental Research, University of Windsor, Windsor, ON, CANADA. **Mechanisms and Function of Food Webs in Large Freshwater Lakes: Lake Ontario as a Model.**

While much work has been done on food web structure and function in lake ecosystems, extrapolating this work may not be appropriate for large lake systems such as Lake Baikal, the African Great Lakes, or the Laurentian Great Lakes. We used the Laurentian Great Lakes as a model system to examine the current understanding of food web structure and function in large freshwater lakes and identify key knowledge gaps. A conceptual diagram is presented to facilitate description of food web function, and is discussed with respect to Lake Ontario. This diagram describes overarching structural attributes of food webs (energy flow into a system and within and among spatial compartments) and connects these with natural processes and human modifiers impacting these attributes. *Keywords: Food chains, Trophic level, Spatial distribution.*

J

JABBARI, A.[1], BOEGMAN, L.[1], MACKAY, M.[2], HADLEY, K.[3], PATERSON, A.M.[3], JEZIORSKI, A.[4], NELLIGAN, C.[4], and SMOL, J.[4], [1]Environmental Fluid Dynamics Laboratory, Department of Civil Engineering, Queen's University, Kingston, CANADA; [2]Science and Technology Branch, Environment Canada, Toronto, CANADA; [3]Ontario Ministry of the Environment and Climate Change, Dorset Environmental Science Centre, Dorset, CANADA; [4]Paleoecological Environmental Assessment and Research Lab, Biology Department, Queen's University, Kingston, CANADA. **Numerical simulations of dissolved oxygen concentrations in Lake Trout lakes.**

Lake Trout are cold water species that live within narrow temperature and dissolved oxygen (DO) boundaries in the hypolimnia of a relatively small number stratified lakes. Consequently, they are vulnerable to environmental stressors including climate change. Climate warming may deepen the thermocline and increase the duration and strength of thermal stratification; reducing the habitat quality of Lake Trout lakes through enhanced DO depletion. We address this issue in a 3-part study that analyzes sediment cores to understand the past, develops empirical formulae to model the present and applies computational models to forecast the future. Here, a simple DO sub-model is added to the 1D bulk mixed-layer thermodynamic Canadian Small Lake Model, which is being incorporated into the Environment Canada's climate modelling systems. The DO model is calibrated and validated by hindcasting temperature and DO profiles from 2 Ontario Lake Trout lakes: a) 5 years of high-frequency (10 s-10 min) data from Eagle Lake, and b) 30 years of biweekly data from Harp Lake. The model can predict the temperature and DO profiles with RMS error <1.5 °C and <3 mg/L, respectively. This model may be generalized for application to other Ontario lakes, including the Great Lakes, to help managers gain a better understanding of future changes in fish habitat. *Keywords: Climate change, Lake trout, Oxygen.*

JACKWOOD, R.W., MAYHER, M.L., BARNSWELL, K.D., and DWYER, D.F., University of Toledo, Lake Erie Center, 6200 Bayshore Road, Oregon, OH, 43616, USA. **Remediation and Restoration Strategies to Reduce Non-point Source Pollutants Entering Lake Erie.**

The Wolf Creek watershed was identified as a proximal source of contamination to the public beach at Maumee Bay State Park, which frequently issues swim advisories due to elevated densities of *Escherichia coli* and harmful algal blooms (HABs). Funding from the US EPA - GLRI was used to implement a two-stage treatment system consisting of restored riparian and wetland habitats to reduce bacteria and nutrient loadings to Lake Erie. A restored riparian zone (upstream) removes bed sediment and sand-sized particles and the restored wetland (downstream) removes dissolved nutrients and bacteria. Significant improvements in water quality have been measured with overall mean (n=121) reductions in the levels of *E. coli* (69%), suspended solids (SS, 18%), orthophosphate (OP, 86%), and total phosphorus (TP, 17%) within the restored riparian zone; mean (n=15) reductions in *E. coli* (87%), SS (55%), OP (35%), and TP (43%) were observed within the wetland. The success of this project suggests that improvements in water quality for the western Lake Erie basin may be obtained via restoration as part of the goal to attain the International Joint Commission's (IJC) recommended 39% reduction in the annual TP loading to Lake Erie to reduce the frequency and severity of HABs. *Keywords: Pollutants, Remediation, Wetlands.*

JAMES, A.L.[1], CHUTKO, K.[2], PRESCOTT, M.[1], and MACRAE, M.L.[3], [1]Dept. of Geography, Nipissing University, 100 College Drive, North Bay, ON, P1B 8L7, CANADA; [2]Dept. of Geography and Planning, University of Saskatchewan, 117 Science Place, Saskatoon, SK, S7N 5C8, CANADA; [3]Dept. of Geography and Environmental Management, University of Waterloo, 200 University AveWest, Waterloo, ON, N2L 3G1,

USA. **Investigating Seasonal Variation and Surrogate Measures of Phosphorus Loading to Lake Nipissing, ON.**

Riverine concentrations of total phosphorus (TP) in the 235 km^2 Wasi watershed have regularly exceeded provincial water quality guidelines since monitoring began in 2009. Surface water sampling has however, focused on summer baseflow conditions, which typically account for less than 20% of TP loads, suggesting there could be significant uncertainty in estimates of riverine P loading downstream to Callander Bay, Lake Nipissing. A municipal source of drinking water, the bay has experienced harmful algae blooms and investigations of internal and upstream P sources are the focus of new research. In 2014 high frequency monitoring of turbidity, temperature, specific conductance and storm-based water quality (TSS, TP, DRP, water isotopes) was initiated at an Environment Canada gauging station located at the mouth of the Wasi river to investigate timing, magnitude and speciation of P to Callander Bay. Contemporary studies have shown that turbidity is a useful surrogate for TP concentrations but that relationships may be harder to quantify during periods when dissolved P flux is larger. This paper will investigate surrogate relationships (e.g. TP vs Q, EC, turbidity) and seasonal variation in speciation for spring-fall storm and freshet sampling from a mixed landuse watershed in the headwaters of Georgian Bay.
Keywords: Water quality, Nutrients, Watersheds.

JAVED, A.[1], VISHA, A.[1], GHANDHI, N.[2], BHAVSAR, S.P.[2], and ARHONDITSIS, G.B.[1], [1]University of Toronto Scarborough, Department of Physical & Environmental Sciences, 1265 Military Trail, Toronto, ON, M1C 1A4, CANADA; [2]Ontario Ministry of Environment and Climate Change, 125 Resources Road, Toronto, ON, M9P 3V6, CANADA. **A Bayesian Assessment of Contaminant Temporal Trends in Lake Erie Fish Communities.**

Consumption of the Great Lakes fish has been identified as one of the leading exposure routes to various contaminants within the human body. In particular, polychlorinated biphenyls (PCBs) and total mercury (THg) are two major contaminants of concern due to their property to restrict the use of valuable commercial and recreational fisheries within the Great Lakes. This study examines the temporal trends of PCBs and mercury in Lake Erie fish by using 40 years of contaminant data collected from the Ontario Ministry of Environment and Environment Canada. Dynamic linear modelling analysis of fish contaminant data showed increasing trends of THg levels in Lake Erie around the end of 1990s. In addition, our analysis suggests that PCB concentrations have been steadily decreasing but these rates were weak. Plausible explanations for the limited response of Lake Erie to contamination reduction strategies include the introduction of non-native species and their impact on trophodynamics along with the role of sediment as a contaminant source.This research will ultimately help elucidate the temporal variability of contaminants in important fish species and shed light on ecological mechanisms that may play a critical role in driving these trends. *Keywords: Lake Erie, Polychlorinated biphenyls, Mercury, Fish toxins.*

JAWAID, M., ALLAN, B., and BRINSMEAD, J.K., Ministry of Natural Resources and Forestry, 2284 Nursery Rd., Midhurst, ON, L0L 1X0, CANADA. **Tench Eradication Project - Midhurst District, MNRF.**

In June 2014, The Ministry of Natural Resources & Forestry (MNRF) was informed of an infestation of Tench (*Tinca tinca*) in a private pond that was connected through a top draw water control structure to the Humber River watershed. While this was the first known occurrence of Tench in the province, it was, and continues to be, believed that if Tench establish in the province, native fish and mollosc populations may decline. A Tench Eradication Project was initiated to remove Tench from the pond, and a project plan was developed to streamline eradication decision making in the field. A number of physical strategies to remove the fish were used including: electrofishing, netting, and pumping. When these physical strategies proved insufficient, the pond was treated with the pesticide Rotenone. The chemical treatment appeared to be effective within 1 hour of application. Tench and other fish species of variable sizes were recovered from the pond, and the chemical appeared to have no impact on other non-fish species that were noted feeding on the dead fish. While it is difficult to confirm with absolute certainty whether the Tench have been successfully eradicated, sampling of the pond and nearby watercourses after the treatment did turn up any additional Tench. *Keywords: Humber River, Invasive species, Monitoring.*

JAZI, S.D. and WELLS, M.G., University of Toronto Scarborough, Toronto, ON, M1C1A4, CANADA. **Particle Deposition Beneath Sediment Laden Plumes.**

When a sediment-laden river enters a stratified lake, it is of great interest to know how fast the sediment settles from the base of the resulting surface or subsurface plume. Generally it is assumed that the location of the settled sediment depends on the Stokes settling velocity of individual or flocculated particles. However, double-diffusive "sediment fingering" can occur arise due to the diffusion of heat (or salt) being much faster than the Brownian diffusion of sediment, which can enhance the sedimentation rate of particles beneath the plume. In previous experiments with a sediment-laden fluid overlying a saline layer, visual measurements can only be made in the optically clear lower layer. We used an Acoustic Doppler Velocimeter to measure the velocity and turbulence of the flow field above and below the initial sediment/salt interface. Velocities of the sediment fingers in the lower layer are always larger than the Stokes settling velocity of the particles. Convection in the upper layer is only significant when sediment fingers dominate, which occurs for marginal density differences between the two layers. We conclude that double-diffusive sediment fingers control sedimentation beneath interflows in most lakes, whereas settling-driven convection is dominant in most oceanic overflows. *Keywords: Hydrodynamics, Sediment transport, Water currents.*

JENKINSON, R.W.[1], BENOY, G.A.[1], ROBERTSON, D.M.[2], and SAAD, D.A.[2], [1]International Joint Commission, Ottawa, ON, CANADA; [2]United States Geological Survey, Middleton, WI, USA. **Nutrient Delivery in the Red-Assiniboine River Basin using a Binational SPARROW Model.**

Excessive phosphorus (TP) and nitrogen (TN) inputs from the Red-Assiniboine River Basin (RARB) have been linked to eutrophication of Lake Winnipeg. The RARB straddles the Canadian-United States border and includes portions of two provinces and three states. This study represents the first large-scale, binationally-focused application of SPAtially-Referenced Regressions on Watershed attributes (SPARROW) models to estimate TP and TN loads and sources by jurisdiction and watershed at multiple spatial scales. TN and TP SPARROW models for 2002 were calibrated using agricultural inputs, forests and wetlands, point sources, and stream channels as sources and atmospheric deposition as sources. At the RARB outlet, downstream from Winnipeg, Manitoba, the majority of the delivered TP and TN came from the Red River watershed (90%), followed by the Upper Assiniboine River watershed and the Souris River. Agriculture was the single-most important TP and TN source for each major watershed, province, and state. Performance metrics for the RARB SPARROW model compare well with other U.S. SPARROW models making it a potentially useful tool to estimate nutrient sources and loads delivered to Lake Winnipeg. *Keywords: Water quality, Modeling, Watersheds.*

JOHNS, C.M.[1] and GARRICK, D.[1], [1]Ryerson University, Jorgenson Hall 706, Toronto, On, M5B2K3, CANADA; [2]McMaster University, 1280 Main Street W, Hamilton, On, CANADA. **"Water Governance Frameworks and Water Governance Indicators: Transboundary and International Applications.**

This article reviews the state of knowledge and growing literature on transboundary water governance and environmental regime effectiveness. The first section examines the range of theoretical approaches and research frameworks being used by different disciplines and research groups to examine complex water governance systems. The second section examines the variety of methodologies for conducting transboundary research on complex water governance systems with a special emphasis on the growing interest and research

related to governance indicators. This section includes an overview and critique of the OECD's recent initiative to develop and apply water governance principles and indicators and explores the potential application of these indicators at different scales in the Great Lakes region. Finally, we outline the theoretical and methodological requirements and challenges of moving forward with research on this frontier. *Keywords: Environmental policy, Indicators, Great Lakes basin.*

JOHNSON, L.B.[1], KOVALENKO, K.E.[1], HOST, G.E.[1], BRACEY, A.M.[1], BRADY, V.J.[1], BROWN, T.N.[2], CAI, M.[1], CIBOROWSKI, J.J.H.[3], DANZ, N.P.[4], GATHMAN, J.P.[5], HOWE, R.W.[6], NIEMI, G.J.[1], and REAVIE, E.D.[1], [1]University of Minnesota Duluth, 5013 Miller Trunk Hwy, Duluth, MN, 55811, USA; [2]US EPA MidContinent Ecology Division, London Road, Duluth, MN, 55812, USA; [3]University of Windsor, Department of Biology, Windsor, ON, CANADA; [4]University of Wisconsin Superior, Department of Biology, Superior, WI, USA; [5]University of Wisconsin River Falls, Department of Biology, River Falls, WI, USA; [6]University of Wisconsin Green Bay, Department of Biology, Green Bay, WI, USA. **Great Lakes Environmental Indicators (GLEI): New tools for Assessing Condition of Coastal Ecosystems.**

Successful restoration requires data capable of depicting stress types, sources and intensity to facilitate evaluation, planning, and execution. Sampling across GL coastal ecosystems has generated WQ and biological data calibrated to the full gradient of stressors and quantified diatoms, invertebrates, plants, fish, amphibians and bird communities within coastal zone ecosystems. Three approaches for identifying indicators have been assessed for correctly identifying conditions in these ecosystems: Index of Ecological Condition (IEC), Weighted Averaging (WA), and Indices of Biotic Condition (IBI). We will discuss validation of existing indicators and describe new indicators for non-wetland coastal ecosystems. We show that there are often two thresholds across the stressor gradient; one where sensitive species simultaneously disappear, suggesting a significant loss of biodiversity. The second at higher stress, representing dominance of tolerant species. Birds, fishes, invertebrates, and plants are affected at a similar threshold suggesting that there are likely to be significant changes in ecosystem function at these points. Therefore, indices could be calibrated to identify these critical points as biological criteria. We will present maps that rank risks of to coastal ecosystems for all GL watersheds based on these thresholds. *Keywords: Assessments, Stress-effect, Bioindicators, Coastal ecosystems.*

JOHNSON, L.T.[1], KING, K.W.[2], WILLIAMS, M.R.[2], CONFESOR, R.B.[1], and BAKER, D.B.[1], [1]Heidelberg University, 310 E. Market St., Tiffin, OH, 44883, USA; [2]Mark R. Williams1 - Research Agricultural Engineer, USDA-ARS Soil Drainage Research Unit, 590

Woody Hayes Dr., Columbus, OH, 43210, USA. **Linking 4R nutrient stewardship at the farm to water quality from the field to watershed.**

The re-eutrophication of Lake Erie is linked to increased dissolved reactive phosphorus (DRP) loads from agricultural watersheds. In response, a 4R certification program for nutrient service providers in the Western Lake Erie Basin (WLEB) began in March 2014. Since then, 25 branches have been certified covering over 1 million acres of the WLEB. The goal of this study was to examine water quality data from the edge-of-field to watershed scales for evidence of the benefits of 4R nutrient stewardship. The potential effects of some of the 4Rs (right time, right place) were quite clear in the data. The application of fertilizer just prior to precipitation, especially without incorporation, lead to large spikes in DRP concentrations that could be detected from the field to watershed scales. Yet other aspects of the 4Rs were not as easy to observe in the data and will require a manipulative experiment. For example, although manure application appeared to be linked with higher losses, manure in these observations was not applied at the right rate for P and hence manure as a source of P was difficult to assess. Together these results show that adherence to 4R nutrient stewardship will play a key role in attaining the 40% decrease in DRP loads needed to reduce the frequency of harmful algal blooms in western Lake Erie.
Keywords: Nutrients, Harmful algal blooms, Tributaries.

JOHNSON, R.J., PÉREZ-FUENTETAJA, A., FLECK, S.J., CLAPSADL, M.D., and SNYDER, R.J., SUNY Buffalo State, 1300 Elmwood Avenue, Buffalo, NY, 14222, USA. **Emerald Shiner Prey Item Analysis in the Upper Niagara River.**

Emerald shiners (*Notropis atherinoides*) are a valuable food source for many predatory fish and piscivorous birds in the Niagara River, including the NY State threatened common tern. However, little research has been conducted to identify the organisms that emerald shiners prey upon, particularly in the Niagara River watershed. A diet analysis was conducted on emerald shiners captured in 2014 from eleven sites in the Upper Niagara River. The fish used for this study represented three size classes (<60 mm, 60-84 mm, and >85 mm) collected from May to October. Prey items were identified, measured and weighed (dry and ash-free dry weights), and biomass of prey items was calculated using length-weight regressions. A few of the stomachs were empty and some contained sand, algae or items not quantifiable. Several stomachs contained nematodes, trematodes, or unknown worms believed to be parasites. The dominant prey items found in the stomachs were cladocerans, chironomids (larvae, pupae and adults), and copepods. Consistent with prior studies, spine barbs of *Bythotrephes* were found rather than whole bodies of this cladoceran, suggesting spine retention. This diet study helps to understand the river resources that sustain this key

prey species in the Niagara ecosystem and identify ontogenetic diet shifts in this species. *Keywords: Zooplankton, Fish diets, Niagara River.*

JOHNSON, T.B.[1], FISK, A.T.[2], HALFYARD, E.A.[2], and STEWART, T.J.[2], [1]Ontario MNRF - Lake Ontario Fisheries Station, 41 Hatchery Lane, Picton, ON, K0K 2T0, CANADA; [2]GLIER - University of Windsor, 401 Sunset Ave, Windsor, ON, N9B 3P4, CANADA. **Post-stocking Behaviour, Habitat Use, & Survival of Hatchery-reared Bloater Using Acoustic Telemetry.**

The Lake Ontario Committee of the GLFC plan to re-establish a self-sustaining deepwater cisco population within 25 years. As part of this initiative, fertilized Lake Michigan Bloater eggs (*Coregonus hoyi*) have been reared to juvenile stages in New York and Ontario hatcheries prior to stocking. The issue is that we do not know what will happen to the stocked fish after introduction. Do hatchery fish survive in the wild and does survival change through time? Do stocked Bloater quickly disperse or stay close to the stocking site? Do they school closely together and move as group? To address these questions, we implanted yearling bloater (21-96 g) with acoustic transmitters and established a receiver array in eastern Lake Ontario . Long-term (6 mo.) laboratory survival of implanted fish was >96% with no evidence of reduced growth or performance. In November 2015, 70 acoustically tagged Bloater were released as part of a larger stocking event. Twenty one days later, a partial download of the array had detected >95% of the individual fish, amounting to over 107,000 individual detections. We describe preliminary patterns in distribution and behaviour based on the partial download ; the remaining array will be downloaded in the spring of 2016 and subject to a more comprehensive analysis. *Keywords: Lake Ontario, Bloater, Telemetry.*

JOHNSTON, C.M.[1], SAAD, D.A.[2], and ROBERTSON, D.M.[2], [1]U.S. Geological Survey, New England Water Science Center, 331 Commerce Way, Pembroke, NH, 03275, USA; [2]U.S. Geological Survey, Wisconsin Water Science Center, 8505 Research Way, Middleton, WI, 53562, USA. **Accessing SPARROW Model Results Through Online Tools.**

SPARROW (SPAtially-Referenced Regressions On Watershed attributes) models have been developed at various scales and locations throughout North America to describe the sources and transport of contaminants (such as nutrients) from streams and rivers to downstream receiving waters. The models require extensive amounts of data to describe contaminant sources and watershed characteristics and are calibrated against observed loads at 100s to 1,000s of monitoring locations. Model output includes estimated loads at 100,000s to 1,000,000s of stream reaches and requires skill and effort to synthesize the results. Online tools have been developed to enable scientists and decision makers to easily view and utilize

model results through a web browser. These tools allow the user to do simple functions, such as mapping the results at various scales and levels of aggregation. The tools also allow for the evaluation of complex "what if" scenarios such as impacts of reducing one or more source inputs. Easy access to model results, through online tools, enables scientists and decision makers to better understand where contaminants originate in a watershed, identify the largest sources, prioritize areas based on their relative contributions to downstream areas, and target actions for remediation. *Keywords: Decision making, Modeling, Nutrients.*

JOHNSTON, J.W.[1], THOMPSON, T.A.[2], BAEDKE, S.J.[3], ARGYILAN, E.P.[4], LEPPER, K.[5], LOOPE, H.M.[2], MORRISON, S.[1], and WILCOX, D.A.[6], [1]Department of Earth and Environmental Sciences and Water Institute, University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L 3G1, CANADA; [2]Indiana Geological Survey, Indiana University, 611 North Walnut Grove Avenue, Bloomington, IN, 47405-2208, USA; [3]Department of Geology and Environmental Science, James Madison University, Memorial Hall 7335, MSC 6903, Harrisonburg, VA, 22807, USA; [4]Department of Geosciences, Indiana University Northwest, 3400 West Broadway, 236 Marram Hall, Gary, IN, 46408, USA; [5]Optical Dating and Dosimetry Lab, Department of Geosciences, North Dakota State University, P.O. Box 6050/2745, Fargo, ND, 58105, USA; [6]Department of Environmental Science and Biology, SUNY-The College at Brockport, 350 New Campus Drive, Brockport, NY, 14420, USA. **Unravelling the natural rhythm of the Upper Great Lakes preserved in ancient shorelines.**

To place historical events into context and plan for future plausible scenarios, we must develop a long-term perspective or understanding of natural variability before the influence of humans. For more than two decades, our Great Lakes research team has developed novel methods and an approach to extract accurate elevations and ages from ancient shorelines, called "beach ridges," to create paleohydrographs that we merge with data from instruments. This method requires compiling subsurface information from (1) individual beach ridges across strandplains of beach ridges to create site paleohydrographs and (2) multiple strandplains within a lake basin to create outlet paleohydrographs. A specific subsurface sedimentary contact preserved in beach ridges provides the most accurate elevation of the water plane deduced from geologic data to date. Optically stimulated luminescence was used as an alternative to radiocarbon dating to better correspond with measured subsurface elevations. By consistently collecting elevations and ages from multiple beach ridges, we have defined lake-level fluctuations to six millennia with a multi-decadal resolution. Systematic patterns in strandplains suggest that three natural superimposed changes in water level and sediment supply occurred on decadal, centennial, and millennial scales. *Keywords: Water level fluctuations, Paleohydrograph, Coasts.*

JONES, N.E.[1] and MACKERETH, R.W.[2], [1]Ontario Ministry of Natural Resources and Forestry - Trent University, 1600 East Bank Drive, Peterborough, ON, K9L 0G2, CANADA; [2]Ontario Ministry of Natural Resources and Forestry - Lakehead University, 955 Oliver Rd, Thunder Bay, ON, P7B 5E1, CANADA. **Resource Subsidies from Adfluvial Fish Increase Stream Productivity.**

The importance of potamodromous migrations and the subsidies they provide to stream ecosystems has received little attention. We determine the importance of excretion, eggs, milt, and carcasses as nutrient and energy sources from a large population of migrating suckers into a small (10m wide) oligotrophic tributary of Lake Superior. In total there was an estimated 5,635 kg of eggs, 2,025 kg of milt, and 1 kg of carcasses from suckers that spawn in the Cypress River. Relative to other mainly non-native fishes, suckers provided 92% of the annual egg biomass and 95% of the milt. Suckers provided 84% and 78% of the annual subsidies of N and P. Epilithon biomass was over nine times more abundant, benthic invertebrate densities were more than two times higher, and fish biomass was eight times greater compared to non-subsidize sections. Stable isotope mixing models revealed that eggs constituted ~50% of the diet of resident fishes. Suckers provided a large subsidy, greater than all other fishes, without mass mortality and significantly enhanced the productivity of the recipient river system. *Keywords: Productivity, Tributaries, Fisheries.*

JORDAN, N.B. and WU, C.H., Department of Civil and Environmental Engineering, University of Wisconsin-Madison, 1415 Engineering Drive, Madison, WI, 53706, USA. **Coastal Bluff Evolution Adjacent to Shoreline Protection Structures in Lake Michigan.**

Shoreline protection structures such as groins and revetments are commonly employed in the Great Lakes to protect coastal infrastructure and property against bluff erosion. Structures are also known to interrupt longshore sediment transport and disrupt regional sediment budgets, and increase local wave climates. As a result, beaches and bluffs experience accelerated erosion. To date, regional and local impacts of shoreline protection structures on beach and bluff systems have not yet been clearly addressed. This study investigates coastal bluff evolution adjacent to coastal structures on local to regional scales. We use remote sensing, integrated bluff, beach, sediment transport modeling, and field measurements to unravel those interactions. It is found that headland bay beaches are created down-coast of most structures, though their stability is determined by the degree of sediment interruption and wave height amplification. Bluff recession in headland bay beaches is sensitive to wave impact height. The findings have significant implications for public and private stakeholders who must make regional management decisions regarding setback requirements, shoreline protection, and coastal ecosystem health. Finally, we investigate the regional and local effects of erosion mitigation management decision in the Great Lakes. *Keywords: Shore protection, Sediment transport, Lake Michigan.*

JU, J.[1], RUDOLPH, D.L.[1], KING, D.[2], and HUBER, A.[2], [1]Department of Earth and Enironment Science - University of Waterloo, 200 University Ave W, Waterloo, ON, N2L 3G1, CANADA; [2]Soil Resource Group, 50 Crimea Street, Guelph, ON, N1H 2Y6, CANADA. **Fate and Transport of Land Applied Waste Greenhouse Feed Water During Field Infiltration Tests.**

Greenhouse discharges are considered a potential contributor to the formation of algal blooms in Lake Erie. Some of these nutrient feed waters are comparable to other nutrient sources used in agriculture. The land application of feed water can be an appropriate management response to nutrient load issues. In this study, the potential environmental impacts of this land application option were investigated through a collaborative monitoring program established at partner greenhouse operations near Leamington, ON. We hypothesized that the nutrients in feed water applied to crop lands would be attenuated to an acceptable level within the soil profile before reaching the water table. Four field sites were established for controlled plot size experiments. Feed water was applied at the maximum allowed rate with a conservative tracer to the monitored plots in fall and spring. Soil and water samples were collected before and after the land application events and analyzed for nutrients and heavy metals. In this presentation, observations of infiltration processes are discussed and field data sets are compared to illustrate the performance of the land application process relative to environmental impacts. Initial evidence indicates that land application of greenhouse feed waters may represent a promising nutrient management strategy. *Keywords: Harmful algal blooms, Greenhouse, Lake Erie, Wastewater treatment, Nutrients, Land application.*

JURJANS, P.K., Ontario Ministry of Natural Resources, 300 Water Street, Peterborough, ON, K9J 8M5, CANADA. **Using Oblique Imagery to Improve Shoreline Mapping of Lake Simcoe.**

The Ontario Ministry of Natural Resources and Forestry (MNRF) led a recent project to investigate the use of oblique imagery to help improve the shoreline mapping of Lake Simcoe. Oblique imagery was captured in late fall 2014 and delivered as TIF and JPG images to the MNRF. A centre point file was used to access the images via the Hyperlink tool in ArcMap. Past shoreline mapping efforts have relied mostly on the interpretation of ortho imagery. By allowing users to better see under shoreline canopy cover, oblique imagery vastly improved shoreline feature interpretation. By providing a lateral view of the shoreline, oblique imagery also gave a valuable height context, which further improved interpretation of shoreline features. The Provincial Geomatics Service Centre in Peterborough (PGSC) was contracted to first revise and simplify the previous Lake Simcoe shoreline mapping methodology and then update the shoreline mapping. Previous shoreline mapping efforts, based on 2008/2009 ortho imagery, were revisited to determine if changes indicated by the newer oblique imagery were due to real change, or whether features had been incorrectly classified during previous mapping efforts. *Keywords: Lake management, Shoreline mapping, Monitoring, Oblique imagery, Remote sensing.*

K

KALEJS, N.I.[1], HÖÖK, T.O.[1], ZISCHKE, M.T.[1], BEUGLY, J.S.[1], COLLINGSWORTH, P.D.[1], ROSEMAN, E.F.[2], HUNTER, R.[2], and FIELDER, D.[3], [1]Purdue University, West Lafayette, IN, USA; [2]United States Geological Survey, Great Lakes Science Center, Ann Arbor, MI, USA; [3]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 contributed to diversity of spawning units and acted as a source of protection from egg predation. Shifts in land usage and sedimentation led to the loss of nearly all reef structure in inner Saginaw Bay. In recent years, decreased sedimentation 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, reproductive usage, egg deposition, and egg 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: Walleye, Restoration, Saginaw Bay.*

KALUSKAR, S.[1], KIM, D.K.[1], WELLEN, C.[1], MUGALINGAM, S.[2], LONG, T.[3], and ARHONDITSIS, G.B.[1], [1]University of Toronto Scarborough, Department of Physical & Environmental Sciences, 1265 Military Trail, Toronto, ON, M1C 1A4, CANADA; [2]Lower

Trent Conservation, 714 Murray Street, Trenton, ON, K8V 5P4, CANADA; [3]Ontario Ministry of the Environment and Climate Change, 125 Resources Road, Toronto, ON, M9P 3V6, CANADA. **Why Bayesian? Integrating SPARROW with Bayesian Inference Techniques.**

SPAtially Referenced Regressions on Watershed attributes (SPARROW) is a non-linear regression strategy that dissects nutrient loadings into three components: nutrient export from different land uses, land-to-water delivery, and in-stream attenuation. We present Bayesian formulations that account for the uncertainty associated with existing knowledge along with the different types of spatial correlation typically underlying the parameter estimation of watershed models. Our research suggests that dynamic parameter estimation can offer insights into the temporal structural changes associated with watershed functioning. We present techniques for making predictions in areas that have modestly been monitored; a topic not heavily addressed in the literature but of great practical importance. The Bayesian framework proposed has several advantages that are highly relevant to the conservation practices of the Great Lakes, such as the support of management decisions by assessing the confidence of compliance with different water quality standards; the optimization of the value of information gained from on-going water quality monitoring programs; the transfer of information in space which allows the effective modelling of sites with limited information; and the alignment with the policy practice of adaptive management implementation. *Keywords: Spatial analysis, Watersheds.*

KANE, D.D.[1] and CHAFFIN, J.D.[2], [1]Defiance College, Defiance, OH, USA; [2]Ohio State University Stone Lab, Put-in-Bay, OH, USA. **Accuracy of Data Buoys for Monitoring Cyanobacterial Blooms in Lake Erie.**

Real-time data buoys have become a valuable tool for lake managers, water treatment plant operators, and the public to monitor cyanobacterial (cHAB) abundance in Lake Erie. However, the sensors on the buoys are located about 0.6 m from the surface, whereas cHABs can regulate buoyancy and may be over or underestimated by the buoy sensors. The objective of this project was to determine how accurate data buoys are at monitoring for cHABs. Surface water samples (0-2 meter, n=58) were collected next to a data buoy located near Gibraltar Island throughout summer 2015 and analyzed for microcystin, chlorophyll, nutrients, and total suspended solids. Additionally, on a subset of dates (n=13) water was collected at every meter throughout the water column and analyzed with a FluoroProbe to determine cHAB-specific chlorophyll. Chlorophyll and microcystin concentrations measured in surface water samples peaked in late July (116 and 4.7 ppb, respectively) and the buoy cHAB sensor tracked the water sample data very well. The every-meter sampling indicated that cHAB were spread evenly throughout the water column or increased in concentrations towards the surface. 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: Algae, Buoys, Cyanophyta.*

KANE, H.J., GLON, M.G., PANGLE, K.L., and MCNAUGHT, A.S., Central Michigan University, 151 Brooks Hall, Mount Pleasant, MI, 48859, USA. **Distribution and abundance patterns of benthic invasive species in nearshore Lake Michigan habitats.**

The nearshore waters of the Laurentian Great Lakes have been greatly affected by dreissenid mussels, which have increased the interception, retention, and recycling of nutrients in the benthic community. This phenomenon, called the nearshore shunt, has boosted benthic productivity and facilitated subsequent invasions by round goby (Neogobius melanostomus), rusty crayfish (Orconectes rusticus), and bloody-red shrimp (Hemimysis anomala). The goal of our project was to evaluate patterns of benthic invasive species abundance in Lake Michigan across key environmental gradients. We sampled benthic invasive species in nearshore areas of Lake Michigan in May, July and October 2015 at eight nearshore sites in MI, IL, and WI. We found that the abundances of rusty crayfish and round goby were surprisingly low across all of our sites. This is in contrast to the abundance of the mysid shrimp, which was elevated at all of our sites. Using a predictive model, we found that the abundance of these mysid shrimp was negatively correlated with lunar phase and positively correlated with amphipod density. Location and season were also predictors of bloody-red shrimp abundance. Our data suggest that benthic invasive species dominate nearshore communities of Lake Michigan, and that their abundance is driven by habitat quality and nutrient gradients. *Keywords: Crustaceans, Invasive species, Benthos.*

KANG, G.[1], LESHKEVICH, G.[2], and MASON, D.M.[2], [1]Michigan State University,Department of Civil and Environmental Engineering, East Lansing, MI, 48824, USA; [2]NOAA,Great Lakes Environmental Research Laboratory, Ann Arbor, MI, 48108, USA. **Identifying and Quantifying Upwellings in Lake Michigan over past 21 years with Moving Window Method.**

Upwelling is crucial for the ecosystems in the Laurentian Great Lakes, in terms of causing short-term nutrient enrichment of surface waters and redistributing nearshore plankton and benthic species (Heufelder et al., 1990; Barton, 1986). During upwelling, the warmer surface water is replaced by the cooler under-surface water and surface water temperature drop could be an important indicator for detecting upwelling. Scientists have been using field collected temperature data since 1940s in order to identify upwellings in Lake Michigan (Mortimer, 1971). Over the last few decades, the development of satellite technology has made possible monitoring lake surface temperature across a large geographical scale over long periods of time. Based on the existing upwelling detection studies using satellite images (Bolgrien and Brooks, 1992; Steissberg et al, 2005; Plattner et al, 2006), the objectives of this paper and project are to (1) reconstruct a semi-automated upwelling detection algorithm using a moving window method in order to (2) detect, quantify and locate lake wide upwelling events in the Great Lakes based on daily GLSEA sea surface temperature dataset and (3) produce daily upwelling product depicted as a percentile, which is computed from the identified upwelling events in various moving windows. *Keywords: Remote sensing, Upwelling, Satellite technology, Lake Michigan.*

KANGABAM, R.D. and MUNISAMY, G., Department of Environmental Biotechnology, School of Environmental Sciences, Bharathidasan University, Tiruchirappalli, 620024, INDIA. **Ecotoxicological Risk Assessment of Organochlorine Pesticides Residues in Water of Loktak Lake.**

The distribution and concentration of some of the important organochlorine pesticides in the water samples of Loktak Lake were examined seasonally for fifteen pesticides including dichloro-diphenyl-trichloroethane for the first time. Water samples were collected from five location of the lakes and analysed using GC-MS. Ecotoxicological risk assessment of FET was carried out using zebra fish embryos. Human health risk assessment based on drinking water consumption were studied to identify the risk potential. The results show the presence of 11 pesticides in Lake water which ranges from 0.78 ng/l to 2271.19 ng/l. Maximum amount of pesticides were found in rainy and pre monsoon season. The FET shows delay in development activities as well as phenotypic changes. Further the human risk assessment shows higher level of pesticides including Endrin, DDT, Endrin Aldehyde, Aldrin and BHC beyond the Hazard Quotient which is expected to pose a serious threat to the local people depending on lake water and also to the important fauna including the highly endangered *Rucervus eldii eldii* which is only found in the Loktak Lake. The source of this pesticides are mostly from the agricultural runoff bought down by the rivers and agricultural practices in and around the lake. *Keywords: Risk assessment, Pesticides, Wetlands.*

KAO, Y.C.[1], ROGERS, M.W.[2], and BUNNELL, D.B.[3], [1]Michigan State University Department of Fisheries and Wildlife, East Lansing, MI, USA; [2]Tennessee Cooperative Fishery Research Unit, Cookeville, TN, USA; [3]USGS Great Lakes Science Center, Ann Arbor, MI, USA. **How Will Salmonine Stocking Levels, Nutrient Inputs, and Mussel Trajectories Influence Lake Michigan.**

Ecological models are powerful tools for integrating available data within the focal ecosystem and process knowledge accumulated across ecosystems. These models can be used to provide timely evaluation on management scenarios and possible trade-offs. In this study, we updated a Lake Michigan Ecopath with Ecosim ecosystem model to make it a decision-support tool, for evaluating management scenarios of salmonine stockings, nutrient loads, and quagga mussel biomass. We first updated parameters in the Ecopath model to represent the offshore (i.e., >30 m) food web in 2002 and then re-calibrated the Ecosim model against observed biomass time series from 2002 to 2012. To develop simulation scenarios that are informative to management, we acquired inputs from fisheries managers, water quality managers, and researchers in this field. We will present results under scenarios of 50% changes (increase and decrease) in Chinook salmon and lake trout stocking (relative to 2013-14 level), 50% changes in quagga mussel biomass (relative to 2010 level), and 25% changes in nutrient loads (relative to 2008 level). Results will illustrate how food-web structure responds to each combination of scenarios, and inform fisheries and water quality managers of the potential impacts of different management objectives. *Keywords: Ecosystem modeling, Salmonines, Lake Michigan, Nutrients, Fish management, Dreissenids.*

KARATAYEV, A.Y.[1], BURLAKOVA, L.E.[1], MEHLER, K.[1], KARATAYEV, V.A.[2], NALEPA, T.F.[3], BALDRIDGE, A.K.[4], and HINCHEY, E.K.[5], [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, One Shields Avenue, Davis, CA, 95616, USA; [3]Water Center, Graham Sustainability Institute, University of Michigan, 214 S. State St., Ann Arbor, MI, 48104, USA; [4]National Oceanic and Atmospheric Administration Great Lakes Environmental Research Laboratory, 4840 S State Rd., Ann Arbor, MI, 48108, USA; [5]Great Lakes National Program Office, U.S. Environmental Protection Agency, 77 West Jackson Blvd., Chicago, IL, 60604-3590, USA. **Underwater Video is an Effective Tool to Reveal *Dreissena* Spatial Distribution and Biomass.**

Almost every study of *Dreissena* in the Great Lakes has relied on bottom grabs to characterize mussel presence and biomass, but until now, the scale at which mussel cover varies has largely been unknown. In 2015 in collaboration with the U.S. EPA, University Michigan, and NOAA we collected 469 ponar grab samples from 158 sites, and 616 underwater video images to estimate the spatial distribution of quagga mussels in Lake Michigan. We developed a novel method, which analyses video footage recorded from a GoPro camera on a towed benthic sled, to estimate dreissenid cover and biomass. Across 47 sites sampled in Lake Michigan in 2015, we compared *Dreissena* cover and biomass estimates based on 3 replicate ponars vs. 500m-long video transects. Overall, replicate ponar samples yielded very high errors in estimates of dreissenid presence, especially at sites with low to moderate mussel cover, because replicate bottom grabs collect samples at smaller spatial scales than those at which mussel cover typically varies. As a result, this method offers a straightforward, inexpensive (and fun) method to drastically reduce uncertainty in lakewide estimates of *Dreissena* presence, especially in regular monitoring surveys which study a small (<50) number of sites. *Keywords: Great Lakes Restoration Initiative (GLRI), Dreissena, Monitoring.*

KARBOSKI, C.T., GORSKY, D., and BIESINGER, Z., USFWS, 1101 Casey Road, Basom, NY, 14013, USA. **Identifying Lake Trout Thermal and Depth Habitat Preference with Pop-up Satellite Tags.**

Lake Trout (*Salvelinus namaycush*) are a biologically and recreationally important piscivore in Lake Ontario. Sea Lamprey (*Petromyzon marinus*) predation, Alewife (*Alosa pseudoharengus*) induced thiamine deficiency and changing lake characteristics have heavily reduced their numbers, necessitating stocking and Sea Lamprey control to maintain the population. Assessing the ways in which Lake Trout use different depths and thermal habitats can provide important information for management: however, there are few ways to accurately collect this type of data. As part of a larger study, we used continuous-logging pop-up satellite tags (PSATs), attached to 4 Lake Trout, to track depth and temperature preferences from April to August 2015. Preliminary analysis of these data indicate strong diel patterns in activity level. Depth and temperature data indicate high affinity for the hypolimnion and areas just below the thermocline, with periodic vertical excursions into the epilimnion. Through this research, we hope to understand more fully the interactions of these fish with an invasive species dominated food web, and their future in an ever changing system. *Keywords: Lake Ontario, Lake trout, Fish behavior.*

KASTER, J.L.[1], KLUMP, J.V.[1], and HERNANDEZ, H.A.[2], [1]School of Freshwater Sciences, UW-Milwaukee, 600 East Greenfield Ave, Milwaukee, WI, 5320234, USA; [2]El Colegio de la Frontera Sur, Ecosur Avenue, Chetumal, QR, 77014, MEXICO. **Conserving a World Class Lake: Laguna Bacalar Mexico.**

We are planning the development of an international, educational and research field station and marine laboratory in Bacalar, Mexico, located in the southern Yucatan Peninsula. The field station lies within a globally unique ecological complex and environmentally sensitive corridor that dynamically connects terrestrial, freshwater, estuarine, and marine systems, and that has been extensively inhabited by humans, dating back to the Mayans, for well over 3000 years. As Mexico's second largest natural lake, this pristine system also lies at the doorstep of major ecological changes and socio-economic forces driven largely by tourism that are sweeping the Yucatan Peninsula. The Bacalar corridor contains highly transmissive karst geology, dynamic regional groundwater flow regimes, high and low growth tropical forests, dense freshwater/seawater mangrove stands, active sublacustrine springs and deep cenote sinkholes, estuarine gradients, and unique fringing reef areas of the 1000 km long Mesoamerican barrier coral reef. Virtually unknown to the scientific community, the Laguna also contains the worlds largest and most extensive living stromatolite complex. Mangrove forests on this coastal plain are extensive, colonize much of this complex, and are linked closely to the hydrology of the region. *Keywords: Planning, Laguna Bacalar Mexico, Policy making, Field Station Planning, Dreissena.*

KELLY, N.[1], YOUNG, J.[2], WINTER, J.G.[2], and MOLOT, L.[1], [1]York University, 4700 Keele street, Toronto, ON, M3J 1P3, CANADA; [2]Ministry of Environment and Climate Change, 125 Resources Road, Toronto, ON, M9P 3V6, CANADA. **A Synthesis of Multiple Stressors in the Lake Simcoe Watershed.**

Assessments of the ecological health of the Lake Simcoe watershed in relation to nutrient loading are now complicated by considerations of the impact of other stressors, such as the presence of invasive species, continued land use changes, and climate change. In this study, we employ a suite of multivariate statistical analyses to quantify the unique and interactive effects of environmental stressors across various trophic levels and aquatic habitats.Water quality, invasive species, and water temperature, have influenced the community structure of aquatic biota across all habitats and trophic levels. Reductions in phosphorus and contaminant concentrations would improve the ecological health of tributaries. Consecutive rather than concurrent changes in these stressors were associated with simultaneous shifts in phytoplankton and zooplankton community composition, potentially impacting food web dynamics. Interactions among past-use contaminants and physical habitat characteristics appear to be impacting the recovery of benthic invertebrates from profundal habitats. Overall, a combination of multiple stressors operating over micro- to macro-scales (e.g. from nutrients to climate) appear to have impacted the ecological health of Lake Simcoe over the last three decades. *Keywords: Water quality, Invasive species, Multiple stressors, Phosphorus, Climate change.*

KELLY, N.E., NI, F., PERHAR, G., and ARHONDITSIS, G.B., University of Toronto Scarborough, Department of Physical & Environmental Sciences, 1265 Military Trail, Toronto, ON, M1C 1A4, CANADA. **Modelling the Daphnia Metabolome: Insights and Lessons Learned.**

In the face of increasing human impacts on freshwater ecosystems, the field of environmental metabolomics has emerged as a rapid, robust, and informative method for monitoring organism health. The keystone zooplankter, Daphnia,exert disproportionate effects on food web dynamics relative to their abundance, display a high sensitivity to natural

stressors, and thus serve as an indicator of the broader impairments of aquatic ecosystems. Designed around metabolomic data, we have developed an ecophysiological model that considers internal pools of 14 metabolites and hierarchical physiological processes, to shed light on the ecosystem implications of declining Daphnia health. To date, our model has demonstrated that the elevated costs of homeostasis can significantly compromise growth when daphnids are exposed to unbalanced diets. When coupled to a classical Lotka-Volterra food web model, variations in homeostatic strategies and dietary conditions manifested in alternative ecosystem states, characterized by dramatically different algal and zooplankton biomass. Finally, dietary daphnid enrichment and depletion trajectories induced hysteresis effects at the population level, which may offer new insights into the multitude of factors that modulate food web dynamics. *Keywords: Ecophysiology, Zooplankton, Metabolomics, Environmental health, Modeling.*

KELLY, N.I.[1] and LIDDLE, G.[2], [1]Lake Simcoe Fisheries Assessment Unit, Ontario Ministry of Natural Resources and Forestry, York Regional Road 18, Sutton West, ON, L0E1R0, CANADA; [2]Aurora District, Ontario Ministry of Natural Resources and Forestry, Bloomington Road W., Aurora, ON, L4G0L8, CANADA. **Long-term Monitoring of the Lake Simcoe Recreational Fishery: 1961-2015.**

Lake Simcoe hosts the largest inland recreational fishery wholly within Ontario, with most angling effort directed towards lake trout (*Salvelinus namaycush*), lake whitefish (*Coregonus clupeaformis*), yellow perch (*Perca flavescens*) and bass (*Micropterus spp.*). The Lake Simcoe Fisheries Assessment Unit (LSFAU) has monitored the state and trends in the winter and summer recreational fisheries since 1961 through roving angler surveys with a random stratified design. In addition, these surveys fulfill policy 3.6a of the Lake Simcoe Protection Plan and inform management decisions. Since 1961, total estimated effort and catch increased significantly ($p<0.05$) for both winter and summer seasons. Across all years, total estimated effort and catch is significantly higher in winter compared to summer ($p<0.05$), however, more target species are caught in the summer fishery. In 2015, the LSFAU conducted spring and fall angler surveys to better understand relative fishing effort throughout the year. Fishing effort primarily occurred in the winter (67.2%) and summer (21.2%), with some fishing effort in spring and fall (11.6%). Future calibration of spring and fall angler surveys may improve the accuracy of fishing effort estimations. Temporal trends in species-specific catch and effort are analyzed and reported. *Keywords: Lake Simcoe, Fisheries, Monitoring.*

KELSEY, M.K.[1], WHITE, B.[2], BOWDEN, L.[3], FRETZ, P.[3], and STOCKWELL, J.D.[2], [1]Salisbury University, Salisbury, MD, 21801, USA; [2]University of Vermont, Burlington, VT, 05405, USA; [3]ECHO, Leahy Center for Lake Champlain, Burlington, VT, 05405, USA. **Using Public Input to Design Science Exhibits that Promote Public Understanding of Invasive Species.**

In developing exciting and effective science center exhibits, a front-end assessment can be employed to determine public understanding of the exhibit's focus. This ensures that visitor education is maximized and stakeholders' resources are utilized efficiently. This study applied a mixed-methods approach to: (1) capture the public's understanding of aquatic invasive species and their perceptions of prevention practices to reduce said species in Lake Champlain; and (2) provide ECHO Leahy Center for Lake Champlain with evidence-based content to inform design strategies for communicating the science behind invasive species in an exhibit opening in 2016. Qualitative interviews revealed that members of the public were familiar with invasive species threatening the lake and most interested in individual-level prevention methods. A predominantly quantitative survey revealed that (1) frequency with which participants see the lake, (2) the number of lake activities participated in, and (3) education level, were variables that predicted interest in and concern for aquatic invasive species, while (4) membership to free-choice learning centers also predicted interest. Themes emerging from the results of this study created a content framework for the exhibit and provided ECHO with the ability to speak directly to guests' interests. *Keywords: Invasive species, Survey, Public education, Mixed-methods, Exhibit.*

KERKEZ, B., FRIES, K.J., and WONG, B.P., University of Michigan, 2350 Hayward St, Ann Arbor, Mi, 48109, USA. **More Science for the Buck: Real-time Data For the Study of the Great Lakes.**

The emergence of robust and cost-effective wireless communications and cloud services is enabling a new generation of real-time experiments. Rather than simply storing the data for subsequent analysis, we can now guide experiments in real-time to ensure that measurements are taken exactly when and where they are needed the most. We illustrate the power of real-time data through three brief case studies: 1) the real-time control of a robotic boat to adaptively sample algal blooms, 2) measurements of urban runoff water quality using "intelligent" sensor nodes, which autonomously adapt their sampling strategy in response to real-time weather forecasts and changing field condition, and 3) novel drifting satellite platforms for the measurement of over-lake energy fluxes. We discuss the development, benefits and limitations of a cyber-architecture that enabled these studies and highlight the requirements of translating this framework to other studies. *Keywords: Data acquisition, Algae, Air-water interfaces.*

KETTERINGS, Q.M., CELA, S., CZYMMEK, K.J., and CRITTENDEN, S., Cornell University, Department of Animal Science, Ithaca, NY, 14853, USA. **Developing a New P Index for New York with Stakeholder Input.**

The New York Phosphorus Index (NY-PI) is a management tool that ranks farmer fields based on their relative risk of P loss and encourage implementation of management practices that reduce P runoff risk. The 36 certified nutrient management planners surveyed in 2014 identified soil test P, fertilizer P and organic P application rate, timing, and method (source factors) and soil drainage, flooding frequency, flow distance to nearest water body, and soil erosion rate (transport factors) as important factors in the NY-PI. Planners suggested adjusting weighting factors and incentivizing manure incorporation, use of cover crops, setbacks and buffers while discouraging manure application to saturated or frozen soil, near water bodies, on steeply sloped fields, and at high rates without incorporation. Analyses of PI data from 33 327 NY farm fields showed flow distance and soil test P level as main drivers for final scores. Based on these findings, a new NY-PI was proposed. The new NY-PI includes soil test P as a manure application cut-off, determines a field's inherent runoff risk first, and then applies best management practices. The new NY-PI recommends: (1) no manure; (2) manure up to P removal for the crop; (3) manure up to N-based recommendations. In partnership, planner feedback on the proposed PI is currently being obtained. *Keywords: Phosphorus, Runoff risk assessment, Regulations, Stakeholder engagement, Management.*

KIM, D.K.[1], SHIMODA, Y.[1], JAVED, A.[1], MUGALINGAM, S.[2], and ARHONDITSIS, G.B.[1], [1]University of Toronto Scarborough, Department of Physical & Environmental Sciences, 1265 Military Trail, Toronto, ON, M1C 1A4, CANADA; [2]Lower Trent Conservation, 714 Murray Street, Trenton, ON, K8V 5P4, CANADA. **Machine Learning Applications to Ecological Research in Great Lakes.**

We introduce a new paradigm to data analysis to the Great Lakes research. Most ecological data exhibit a variety of problems, including abnormal distributions (multimodality), non-linearity, many zeros (species abundance), multi-collinearity, and other complex data interactions (spatiotemporal autocorrelation). Nonetheless, many modeling strategies have relied on conventional statistical methods, despite the obvious violations of their assumptions. Machine Learning offers a new type of inductive, data-driven strategy. The ever-growing information, triggered by recent technological advancements of data collection, has made compelling the adoption of such heuristic algorithms to support the decision-making process in environmental management. We demonstrate two Machine Learning techniques used in the Bay of Quinte, Lake Ontario. Artificial Neural Networks are applied to characterize watershed land-use and phosphorus export patterns. Evolutionary

Algorithms are also used for time-series water quality forecasting of plankton dynamics. Both methods prove to be robust for non-linear ordination, classification, and rule discovery through data-learning processes. We discuss the prospect of using these techniques in the context of risk analysis and eutrophication management. *Keywords: Bay of Quinte, Machine learning, Eutrophication, Model studies.*

KIMBROUGH, K.L.[1], DAVENPORT, E.D.[1], EDWARDS, M.A.[1], JOHNSON, W.E.[1], PINIAK, G.A.[1], and JACOB, A.P.[2], [1]NOAA/NCCOS, 1305 East West Highway, Silver Spring, MD, 20850, USA; [2]CSS-Dynamac, 10301 Democracy Lane, Suite 300, Fairfax, VA, 22030, USA. **Great Lakes Mussel Watch: Refocusing Contamination Monitoring and Assessment to include CECs.**

NOAA's Mussel Watch Program (MWP) has been monitoring chemical contamination in the Great Lakes since 1992 using dreissenid mussels as indicator organisms. Beginning in 2009, through coordination with Great Lakes Restoration Initiative, MWP expanded its monitoring efforts by adding numerous sites within highly impacted areas and conducting targeted monitoring and contamination assessments, primarily for legacy chemicals. Under the Great Lakes Action Plan II, MWP has initiated monitoring Contaminants of Emerging Concern (CEC) and assessment of the effects of these compounds on mussel health. Most CECs are hydrophilic and do not accumulate in mussels but can have measurable bioeffects on mussel health, hence linking exposure to effects through effects-based monitoring approaches is essential. A pilot study to monitor a broad suite of CECs and associated effects on bivalve health using cellular biomarkers and metabolomics was conducted at Maumee River in Lake Erie in 2015. Polar Organic Chemical Integrative Sampler was co-deployed at a subset of sites, which allows the comparison of CEC uptake and detection in mussels. Retrospective CEC analysis of mussel tissue samples from other Great Lakes sites was also conducted. CEC and relevant legacy chemical data from mussels and preliminary bioeffects data will be presented.
Keywords: Monitoring, Contaminants of emerging concern, Mussels.

KINDREE, M.M. and MANDRAK, N.E., University of Toronto, 1265 Military Trail, Scarborough, ON, M1C1A4, CANADA. **The Effect of Sampling Gear and Effort on the IBI in the Huron-Erie Corridor Areas of Concern.**

In 1987, the International Joint Commission identified the St. Clair and Detroit rivers as Areas of Concern (AOC) in response to ongoing losses of critical fish and wildlife habitat. Implementation of remedial action plans required monitoring of these areas using the Index of Biotic Integrity (IBI) as an indicator of ecosystem health. The IBI is typically calculated for AOCs based on fish community sampling using boat electrofishing; however, site conditions in the Huron-Erie Corridor (HEC) are characterized by high water velocity and depth, which may lead to reduced capture efficiency. This may lead to biases in species captures (and associated IBI scores) relative to other sites in the Great Lakes basin. The influence of sampling gear type on the IBI scores was examined by statistically comparing paired fish community data collected using boat electrofishing and benthic trawling conducted 2011-2014. The IBI scores were not significantly different between gears and among years and seasons. Current sampling efforts account for 75% of the variance in mean IBI scores. The results of this study will provide guidance on the development of long-term monitoring protocols in the HEC. *Keywords: Fish communities, Biological indicators, Fish, Index of Biotic Integrity.*

KINSMAN-COSTELLO, L.E.[1], SHEIK, C.S.[2], BURTON, G.A.[3], SHELDON, N.D.[3], and DICK, G.[3], [1]Kent State University, Kent, OH, USA; [2]University of Minnesota Large Lakes Observatory, Duluth, MN, USA; [3]University of Michigan, Ann Arbor, MI, USA. **Microbial ecology and biogeochemistry of a high-sulfur submerged sinkhole in Lake Huron, MI.**

Submerged groundwater seeps in Lake Huron establish ecosystems with distinctive environmental conditions. In the low-O_2, high-sulfur environment of the Middle Island Sinkhole (MIS) at 23-m depth, a mat dominated by Phormidium and Planktothrix cyanobacteria thrives. However, little is known about organic-rich sediments beneath the mat. We elucidate relationships between microbial community structure and ecosystem function in a unique and environmentally vulnerable ecosystem. The biological and geochemical conditions in the MIS were distinctly different from those in Lake Huron sediments of comparable depth. Communities were diverse and vertically stratified to 12 cm sediment depth. Our high throughput 16S rRNA gene sequencing approach revealed extensive microbial diversity. This diversity was present within microbial groups, including putative sulfate-reducing taxa of Deltaproteobacteria, some of which exhibited differential abundance in the mats and with depth in the underlying sediments. We found evidence for active cycling of sulfur, methane, and nutrients, which were responsible for high concentrations of sulfide, ammonium, and phosphorus in sediments underlying cyanobacterial mats. These results demonstrate the importance of mat-sediment interactions for sustaining this hotspot of diversity and biogeochemistry. *Keywords: Biogeochemistry, Lake Huron, Sediments.*

KLINARD, N., KESSEL, S.T., HALFYARD, E.A., FISK, A.T., and COLBORNE, S.F., Great Lakes Institute for Environmental Research, University of Windsor, 401 Sunset Ave., Windsor, ON, N9B 3P4, CANADA. **Movement and Habitat Use of Sunfish in the Detroit River Revealed Using Acoustic Telemetry.**

In temperate freshwater lakes and rivers Bluegill (*Lepomis macrochirus*) and Pumpkinseed (*Lepomis gibbosus*) are abundant species integral to the structure of their communities as mid-trophic level consumers. Sunfish are most commonly studied in smaller lakes and rivers where Bluegill are typically the more limnetic species, foraging on zooplankton in the water column, compared to Pumpkinseed that use the littoral habitat to forage on a variety of benthic macroinvertebrates. Much less is known about the habitat use of these fish in the Great Lakes and its connecting channels. We focused on the Detroit River, a large river ecosystem that is part of the Huron-Erie Corridor that shares characteristics of rivers, e.g. flowing currents, and lakes, e.g. areas of dense vegetation. This river has both sunfish species, but relatively little is known about how they use the available habitat. We established a gridded acoustic telemetry array along a 700 m section of the Detroit River to monitor the movement patterns of multiple fish species. Sunfish were implanted with internal 180 kHz tags and monitored from June - October 2015. The habitat use of the two species will be compared in the Detroit River and relative to habitat use in smaller waterbodies. *Keywords: Habitats, Detroit River, Acoustics.*

KLUMP, J.V.[1], BRAVO, H.R.[1], LABUHN, S.L.[1], HAMIDI, S.A.[1], FERMANICH, K.[2], BAUMGART, P.[2], and VERHAMME, E.M.[3], [1]School of Freshwater Sciences, U. Wisconsin-Milwaukee, Great Lakes WATER Institute, Milwaukee, WI, 53204, USA; [2]University of Wisconsin-Green Bay, Natural & Applied Sciences, ES 317E, Green Bay, Wi, 54311-7001, USA; [3]LimnoTech, Ann Arbor, MI, USA. **What will it take to restore Green Bay?**

While representing only 7% of the surface area and 1.4% of the volume of Lake Michigan, Green Bay receives approximately one-third of the total nutrient loading within the entire Lake Michigan basin. Hypereutrophic conditions have been a persistent feature of Green Bay throughout most of the last century and have been, along with PCB contamination of the lower Fox River, one of the principal criteria for the southern bay's designation by the IJC as an Area of Concern. Although it has probably been a feature of the system for decades, the occurrence of hypoxia or so-called "dead zones" in Green Bay was not widely recognized until recent studies mapped the extent of oxygen depleted bottom waters in the bay and showed the impact on a depauperate benthic fauna. We have assembled a comprehensive set of linked models of watershed loading, biogeochemical cycling, and hydrodynamics, informed by downscaled regional climate scenarios, that are

designed to identify and assess the effectiveness of various management options within the watershed to restore water quality in the bay both now and under future climate.
Keywords: Green Bay, Hypoxia, Biogeochemistry, Watersheds, Impared water use, Modeling.

KLYMUS, K.E., MARSHALL, N.T., HENNESSY, C., and STEPIEN, C.A., University of Toledo Lake Erie Center, 6200 Bayshore Rd., Toledo, OH, 43616, USA. **High-Throughout Sequencing Assays to Detect Aquatic Invasive Species from Environmental Samples.**

Environmental DNA (eDNA) surveys are being integrated into management plans for the early detection of aquatic invasive species. The technique involves the amplification of DNA from shed cells, or in the case of microscopic organisms, the entirety of the organism, found in water samples, allowing for the identification of taxa based on DNA sequences. High throughput sequencing methods increase the sequencing output and enable the identification of multiple taxa from a single sample, improving the applicability of eDNA tools for surveying native and invasive wildlife. However, few studies have tested the quantitative capability of these sequencing methods. We present data on our current high throughput genetic assays designed to detect invasive, or potentially invasive, invertebrate and fish species in the Laurentian Great Lakes. We place emphasis on designing and testing group specific primers in order to avoid non-target species amplification and amplification bias, a problem that plagues many current applications of metagenetic methods. Using simulated DNA communities and aquarium experiments, we test our assays' abilities to simultaneously identify multiple taxa and measure their relative DNA abundances.
Keywords: Invasive species, Fish populations, Fish management, Mollusks, Genetics, Dreissenid mussels.

KNEE, K.R.[1], SLAWECKI, T.[2], KOCH, K.[2], PAIGE, K.K.[3], MAGUIRE, A.[3], CAMPBELL, L.[1], and GALVARINO, C.[4], [1]RPS ASA, 55 Village Square Drive, Wakefield, RI, 02879, USA; [2]Limnotech, 501 Avis Drive, Ann Arbor, MI, 48108, USA; [3]GLOS, 229 Nickels Arcade, Ann Arbor, MI, 48104, USA; [4]Second Creek, P.O. Box 50960, Columbia, SC, 29250, USA. **MyGLOS: A Customizable View into the Great Lakes Observing System.**

The provision of a data portal allowing users to view and analyze observation and model data is central to the GLOS mission and GLOS has developed several iterations of a portal over the years. In a continuing effort to improve the tools available to users, GLOS is currently developing MyGLOS. The motivation for MyGLOS was to create an easy to use, interactive mapping portal that can be customized by the user. This new product will provide a range of new functionality to users including the ability to 1)search for data by keyword or filter data by category and date range, 2)display search results on a map,

3)connect directly to source metadata in GeoNetwork, 4)create, save, and share custom map views, 5)display historic model, satellite, and limited station data using the Timeslider, 6)create custom time-series plots with multiple parameters from the same station, 7)create virtual buoys to investigate model or satellite data at specific locations, 8)create model-data comparison plots. Additionally, improvements have been made to the technology backend, documentation, and metadata. In particular, the use of GeoNetwork to manage all metadata has improved data discoverability. The MyGLOS framework also provides a flexible backbone for future specialized portals, maps, or "views" that are built within the same structure. *Keywords: Monitoring, Data storage and retrieval, Modeling.*

KNEISEL, A.N.[1], COOPER, M.J.[2], and UZARSKI, D.G.[1], [1]Central Michigan University, Mount Pleasant, MI, USA; [2]Burke Center for Freshwater Innovation Northland College, Ashland, WI, USA. **Impact of *Phragmites* Invasion on Macroinvertebrate Communities in Wetlands of Thunder Bay, MI.**

While it has been well documented that the invasive genetic variant of *Phragmites australis* displaces native plant species, there is less consensus on how it impacts the macroinvertebrates that live among the vegetation. We hypothesized that aquatic macroinvertebrate communities in patches of *P. australis* would have lower diversity than those in patches of native wet meadow species. To test this, we quantitatively sampled aquatic macroinvertebrates from sediment cores and the water column in patches of invasive *P. australis* and from adjacent native wet meadow patches at 5 sites located in Thunder Bay of western Lake Huron. We also sampled a suite of physical and chemical variables, including light penetration, water chemistry, and sediment organic matter. Initial results suggest that macroinvertebrate communities within *P. australis* have lower taxa richness than those in adjacent wet meadow patches. Additionally, light intensity and dissolved oxygen were both lower in *P. australis* patches than in native vegetation. A decrease in taxa richness, potentially linked to reduced dissolved oxygen, light intensity, or other alterations of the ecosystem by *P. australis*, could be indicative of the impact of invasion on other wetland fauna. *Keywords: Macroinvertebrates, Wetlands, Phragmites australis.*

KNIGHT, C.K.[1], JOHENGEN, T.H.[1], and DAVIS, T.W.[2], [1]Cooperative Institute for Limnology and Ecosystems Research, 440 Church St, Ann Arbor, MI, 48109, USA; [2]NOAA Great Lakes Environmental Research Lab, 4840 S State Rd, Ann Arbor, MI, 48108, USA. **Patterns in Space and Time of *Microcystis* Sediment Seed Stock Viability in Western Lake Erie.**

Dense blooms of *Microcystis* have occurred in western Lake Erie for over a decade. Many studies have investigated the ecology of these events during the summer months (June

- October). However, little is known about the potential importance of over-wintering populations of *Microcystis* to the subsequent bloom recruitment process. In order to investigate the abundance and viability of *Microcystis* vegetative seed stocks, and its relationship to harmful algal bloom (HAB) development in western Lake Erie, sediment samples were collected throughout the western basin across a two-year time period. Sample collection occurred during two periods each year. The first sampling occurred just after the initial settling of the bloom in the fall. Sampling at the same sites was repeated the following spring. Quantitative PCR techniques assessed the total and potentially-toxic *Microcystis* densities in the sediments. Spatial and temporal comparisons were accomplished using interpolation tools in ArcMap. Results indicate that both benthic *Microcystis* densities and toxic to total ratios vary both spatially and temporally. Further research will examine the spatial and temporal correspondence between identified resuspension events and bloom promotion at the lake scale. *Keywords: Microcystis, Sediments, Lake Erie.*

KOBILIRIS, D.[1], LONG, T.[2], O'CONNOR, K.M.[3], HIRIART-BAER, V.[4], BOYD, D.[2], HALL, J.D.[3], YERUBANDI, R.[4], and ARHONDITSIS, G.B.[1], [1]University of Toronto Scarborough, Department of Physical & Environmental Sciences, 1265 Military Trail, Toronto, ON, M1C 1A4, CANADA; [2]Ontario Ministry of the Environment and Climate Change, 125 Resources Road, Toronto, ON, M9P 3V6, CANADA; [3]Hamilton Harbour Remedial Action Plan, 1280 Main Street West, Hamilton, ON, L8S 4K1, CANADA; [4]Environment Canada, 867 Lakeshore Rd, Burlington, ON, L7R 4A6, CANADA. **Why Models Should Talk to Each Other? Lessons Learned from the Hamilton Harbour.**

There is a great deal of modelling work that has been done toward establishing realistic water quality goals in the Hamilton Harbour and impartially evaluating the likelihood of delisting the system for the BUI "Eutrophication or Undesirable Algae". There are watershed, eutrophication, and food web models in place that aim to shed light on different facets of the ecosystem functioning. In this study, our objective is to address several critical questions that have emerged from all these projects: To what extent do these models coalesce with respect to their assumptions and inference drawn? Are there any major discrepancies about the role of different ecosystem processes (e.g., sedimentation fluxes, recycling rates, exchanges with Lake Ontario)? What are the major sources of uncertainty that will ultimately determine the attainment of the existing delisting goals? Our aim is to highlight the major lessons learned about the watershed dynamics, the eutrophication phenomena, and the broader implications for the food web integrity. We will also highlight knowledge gaps of our current understanding of the system. Our thesis is that the emphasis on P management has been successful and must remain the focus of the Hamilton Harbour restoration efforts, but there are several "ecological unknowns" that can modulate the system response. *Keywords: Hamilton Harbour, Water quality criteria, Eutrophication, Decision making, Ecosystem modeling, Risk assessment.*

KOCH, K.[1], VERHAMME, E.M.[1], PAIGE, K.K.[2], SLAWECKI, T.[1], and KNEE, K.R.[3], [1]LimnoTech, 501 Avis Dr., Ann Arbor, MI, 48108, USA; [2]Great Lakes Observing System, 328 S. State St., Ann Arbor, MI, 48104, USA; [3]RPS ASA, 55 Village Square Drive, South Kingstown, RI, 02879-8248, USA. **GLOS HABs Data Viewer: How DMAC Helps HABs Data Flow from Researchers to Decision Makers.**

Following the 2014 Toledo Water Crisis, the number of in-situ continuous water quality sensors increased in Lake Erie five-fold in 2015. These new sensors were deployed by a diverse group of federal and academic researchers and by water treatment plants in the region. GLOS and LimnoTech began working with each research group [Ohio State Univ. (Stone Lab), Univ. of Toledo (Lake Erie Ctr), NOAA Great Lakes Environmental Research Lab, and Bowling Green Univ.] to interface with the water treatment plant operators in Toledo, Oregon, Ottawa County, Marblehead, Elyria, Avon, Ashtabula, and Mentor. Once a common data sharing platform was built, GLOS worked to develop an online viewing tool to enable plant operators and researchers to view real-time observations of temperature, pH, conductivity, turbidity, chlorophyll, and phycocyanin from 15 locations throughout Lake Erie. The continuous observations of water quality from this ad-hoc sensor network provided an invaluable resource to drinking water treatment operators that are charged with providing safe drinking water to nearly 2 million residents through Northeast Ohio on a daily basis. This tool demonstrates how a data management plan can bring together a diverse group of stakeholders with overlapping needs and provide added value for each participant in the sensor network. *Keywords: Decision making, Harmful algal blooms, Management.*

KORNIS, M.S.[1], BUNNELL, D.B.[2], SWANSON, H.K.[3], and BRONTE, C.R.[1], [1]U.S. Fish and Wildlife Service, Great Lakes Fish Tag and Recovery Laboratory, 2661 Scott Tower Drive, New Franken, WI, 54229, USA; [2]U.S. Geological Survey, Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105, USA; [3]University of Waterloo, Department of Biology, 200 University Ave. W., Waterloo, ON, N2L 3G1, CANADA. **Spatiotemporal patterns in trophic niche overlap among five Lake Michigan salmonine species.**

In Lake Michigan, lake trout, Chinook salmon, coho salmon, steelhead and brown trout are managed via stocking to support sport fisheries and restore native fishes. Understanding niche partitioning among salmonines after recent shifts in prey fish abundance is critical to fisheries management. We evaluated δ13C and δ15N stable isotope ratios from salmonines and their prey to describe spatiotemporal patterns in niche overlap. Samples were collected from the four quarters of L. Michigan during early and late summer, spanned gradients of fish size, and separated wild and stocked lake trout and Chinook salmon. Lake trout had the most unique trophic niche, with <25% overlap with Chinook salmon, coho salmon and steelhead. Lake trout were enriched in δ15N, indicating more reliance on offshore benthic prey than other species. δ13C was enriched for smaller fish of most species, suggesting more reliance on nearshore energy. δ13C was depleted for wild vs. stocked lake trout, suggesting wild recruitment occurs offshore. Lake trout and brown trout isotopes clustered by region, which may indicate regional fidelity; isotopes for Chinook salmon and steelhead did not, possibly due to inter-regional movement. Our study suggests competition for declining prey fish will be highest among Chinook salmon, coho salmon, brown trout, and steelhead. *Keywords: Salmon, Lake trout, Stable isotopes.*

KOSIARA, J.K. and UZARSKI, D.G., Central Michigan University, Mount Pleasant, MI, USA. **Assessment of yellow perch movement between coastal wetland and nearshore waters of the Great Lakes.**

The movement of organisms across habitat boundaries facilitates the transport of energy and materials and represents an important link between these habitats. In the Great Lakes, yellow perch (*Perca flavescens*) commonly inhabit both coastal wetlands and open water, nearshore environments. However, little is known about how these fish move and therefore provide a link between these habitats. As a recreationally and economically valued fish, management of the species could benefit from an increased understanding of movement patterns. In the summer of 2014 and 2015, yellow perch were collected from both habitats at 16 nearshore-wetland site pairs distributed across the upper Great Lakes. Otolith thin sections were then analyzed from core to edge for Mg, Mn, Sr, Ba, Zn, Cu, and Pb. Edge data from otoliths were used to discriminate wetland and nearshore signatures. Linear discriminant functions were then applied across entire otolith transects to determine habitat use throughout each fish's life. Preliminary results suggest there is a combination of both nearshore and wetland resident fish as well as those that move between habitats one or more times per year. Further work will attempt to explain these patterns and their variability across the basin. *Keywords: Yellow perch, Coastal ecosystems.*

KOVACEVIC, V.[1], SIMPSON, A.J.[2], and SIMPSON, M.J.[2], [1]Department of Chemistry, University of Toronto, 80 St. George Street, Toronto, ON, M5S 3H6, CANADA; [2]Environmental NMR Centre and Department of Physical and Environmental Science, University of Toronto, 1265 Military Trail, Toronto, ON, M1C 1A4, CANADA. **1H NMR Metabolomics of *Daphnia* Responses to Triclosan, Carbamazepine and Ibuprofen Exposure.**

Aquatic environments are under constant threat from exposure to pharmaceuticals and personal care products and the impact of these contaminants may be understood by measuring the metabolome of aquatic organisms. ^{1}H nuclear magnetic resonance (NMR)-based metabolomics in combination with multivariate statistical analysis was used to evaluate the metabolome of *Daphnia magna* after 48 hour exposures to a range of sub-lethal triclosan (6.25-100 µg/L), carbamazepine (1.75-14 mg/L) and ibuprofen (1.75-14 mg/L) concentrations. Sub-lethal triclosan exposure suggests that *D. magna* was under general oxidative stress as noted by increased levels of many amino acids such as the branched-chain amino acids, glutamine, glutamate and methionine. Sub-lethal carbamazepine exposure gave a non-monotonic response as the levels of a majority of metabolites decreased with carbamazepine exposures < 10.5 mg/L, and then increased to control levels with exposures > 10.5 mg/L. Sub-lethal ibuprofen exposure caused contrasting metabolite changes at the lower compared to the higher exposure concentrations and serine, methionine, lysine, arginine and leucine emerged as potential bioindicators. ^{1}H NMR-based metabolomics gave new information on how these emerging contaminants impact *D. magna* on a molecular-level. *Keywords: Metabolism, Metabolomics, Crustaceans, Omics, Environmental contaminants.*

KOVALENKO, K.E.[1], REAVIE, E.D.[1], ALLAN, J.D.[2], CAI, M.[1], SMITH, S.D.P.[2], and JOHNSON, L.B.[1], [1]NRRI, University of Minnesota Duluth, Duluth, USA; [2]University of Michigan, Ann Arbor, USA. **Phytoplankton community change-points across gradients of nutrients and invasive mussels.**

Phytoplankton communities can experience non-linear changes in response to increasing nutrient concentrations. Such information can contribute ecology-based evidence for developing nutrient criteria and allows identification of key species associated with assemblage shifts. This is particularly important for the pelagic regions of large lakes, where few indicators are available, making it difficult to monitor assemblage responses to large-scale stressors. We analyzed Great Lakes phytoplankton assemblage responses to nitrogen deposition, invasive *Dreissena* densities and *in situ* nitrate and phosphorus concentrations using Thresholds Indicator Taxa Analysis (TITAn), an approach that integrates responses of many taxa to determine cumulative community responses along environmental stress gradients. We observed non-linear changes in phytoplankton assemblages in response to major nutrients (lake TP and nitrate concentrations and atmospheric N loading) and *Dreissena* abundance and identified new phytoplankton indicators of anthropogenic stress. Since pelagic phytoplankton directly respond to many stressors associated with human development, their responses can provide early-warning signals for community change in response to stress. *Keywords: Phytoplankton, Nutrients, Indicators.*

KOZEL, C.L. and MARSDEN, J.E., University of Vermont, 3 Co, Burlington, VT, 05401, USA. **Diet of Young-of-the-Year and Juvenile Lake Trout in Lake Champlain.**

Little is known about the diets of wild, young-of-the-year (YOY) and juvenile lake trout in the Laurentian Great Lakes and Lake Champlain. Lake trout have been stocked since 1972 in Lake Champlain but less than 3% of adults in fall spawning assessments are wild; all stocked fish are marked with fin clips. In 2015 we collected 128 lake trout juveniles ranging from 65-310 mm, of which 51 (39.8%) were unclipped and comprised three year classes. We examined diets of YOY and juvenile lake trout to investigate the potential for feeding competition between wild and stocked fish. Length, weight, and gut content and mass were recorded from all fish; stomach contents were identified to the species (fish) and family (zooplankton). Wild lake trout diets were dominated by *Mysis* (69.5%) and rainbow smelt (11.9%) while stocked fish diets consisted of 44.7% rainbow smelt, 23.8% *Mysis* and 19.6% slimy sculpin. Stomachs also contained alewife, trout perch, yellow perch, *Daphnia*, and copepods. These data indicate that there is an overlap in diet between wild and stocked lake trout but stocked fish have a wider forage base. The recent recruitment of wild juveniles may be due to changes in prey availability; diet analysis could lead to a better understanding of factors that affect restoration of lake trout. *Keywords: Lake trout, Fish diets, Fisheries.*

KRANTZBERG, G., McMaster University EPP, 1280 Main St. W, ETB 510, Hamilton, ON, l8s4k1, CANADA. **Nearshore Governance That Is Inclusive of Science and Policy Making.**

An innovative, knowledge-based partnership between research scientists and resource managers in the region could provide the foundation for better bilateral and management of this shared system. For such a partnership to be successful, we need to recognize and minimize the potential for miscommunication. A major reason why scientists and policy makers disengage is because the scientific community tends to consider the "resource" as the starting point and the policy maker considers the "social consequences" of resource use as a starting point. Scientific communication and policy making operate according to very different time schedules. Being sympathetic to these dynamics can move our region toward a successful science/policy synergy. As decisions surrounding nearshore programs and policies evolve, so should our governance structures and rules of accountability. Determining how to translate scientific findings into operable governance instruments leads to a form of investigative inquiry that could result in more successful paradigms for regenerating Great Lakes excellence *Keywords: Policy making, Environmental policy, Decision making.*

L

LABUHN, K.A. and CALAPPI, T.J., U.S. Army Corps of Engineers, 477 Michigan Ave, Detroit, MI, 48226, USA. **Conveyance Change in the St. Clair River.**

The U.S. Army Corps of Engineers is tasked with regulating discharge and monitoring water levels of the Great Lakes, the largest surface freshwater system on Earth. As part of this mission, and as a result of the longest recorded period of below average water levels on Lake Michigan and Lake Huron, the Corps of Engineers monitors the conveyance capacity of the St. Clair and Detroit rivers, the connecting channel between Lake Huron and Lake Erie. These are the only connecting channels on the Great Lakes without actively operated flow regulating structures. One of the datasets necessary to accomplish this mission is the regular collection of swath bathymetry. These data were collected in 2007 and 2012 on the St. Clair River. The original conveyance capacity analysis was cut-fill and depth change. Both comparisons were completed with and without accounting for the survey error budget. Multidimensional numerical models with both sets of geometry were developed and used to compliment the bathymetric data analysis. Development and results of the numerical modeling will be discussed. Preliminarily, the bathymetric data analysis and the numerical model are in agreement on conveyance change since 2007. Conveyance monitoring is planned to continue until any trends can be identified and statistically verified. *Keywords: St. Clair River, Hydrodynamic model, Outlets.*

LABUHN, S.L.[1], WILCOX, E.M.[2], VALENTA, T.[2], QUALLS, T.[2], KLUMP, J.V.[1], and KENNEDY, J.[2], [1]University of Wisconsin-Milwaukee School of Freshwater Sciences, 600 E. Greenfield Ave, Milwaukee, Wi, 53204, USA; [2]NEW Water, 2231 N. Quincy St, Green Bay, WI, 54302, USA. **Estimating summertime primary production via in-situ monitoring in Green Bay, Lake Michigan.**

Quantifying the rates and fluctuations of primary production and carbon respiration is fundamental to understanding ecosystem function. This study utilized high resolution time series (30 minute) buoy-based in situ sensor data, from two sites, to estimate daily primary production and respiration rates during most of the summers from 1986 to 2015 in the eutrophic freshwater embayment of southern Green Bay, Lake Michigan. Highly coherent diel oscillations in dissolved oxygen in epilimnetic waters were observed from the GLOS buoy sensor array (NOAA 45014) and from a GBMSD monitoring site for much of the summer. Corrections for air-sea exchange based upon wind speed derived gas exchange coefficients and saturation state, when combined with mixing depth, allow calculation of day time net oxygen production and night time respiration. Results indicate that during most of

the summer southern Green Bay tends slightly towards autotrophy. For 2014 and 2015 during which a nearly continuous sensor record exists at the GLOS buoy, cumulative net ecosystem production during the period of early June to late September was estimated to be 3.2 and 1.3 mol C m-2, and is sufficient to drive a significant portion of benthic respiration, the principal cause of seasonal hypoxia. *Keywords: Productivity, Observing systems, Monitoring.*

LAFONTAINE, J.E., DROUILLARD, K.G., and GRGICAK-MANNION, A., GLIER - University of Windsor, 401 Sunset Ave, Windsor, On, N9B3p4, CANADA. **Spatial Contaminant Patterns of Metals in a Great Lakes Area of Concern.**

Sediment Samples from the Huron-Erie Corridor (HEC) (St. Clair River, Lake St. Clair and Detroit River) were collected using a stratified-random approach in a 2013-2014 survey to evaluate sediment chemistry. The results are compared and contrasted with a similar study conducted in 2004. The sediment chemistry analyses consisted of grain size, TOC, total mercury, trace metals, PCBs, PAHs and OCs. At the corridor scale there were distinct differences noted in the distribution of organic and metal contaminants. Temporal comparisons yielded distinct changes with respect to certain trace metals ($p<0.001$) while others were shown to display no change with time. A Geographic Information System (GIS) was used to map and assess hazard index information while the Getis-Ord GI* geospatial statistic tool was used to characterize regional zones of high and low contamination for selected contaminants. *Keywords: GIS, Detroit River, Metals, St. Clair River.*

LAM, W.V.[1], MACRAE, M.L.[1], ENGLISH, M.[2], O'HALLORAN, I.P.[3], and WANG, Y.T.[3], [1]University of Waterloo, 200 University Ave. West, Waterloo, ON, N2L 3G1, CANADA; [2]Wilfrid Laurier University, 75 University Ave. West, Waterloo, ON, N2L 3C5, CANADA; [3]University of Guelph, Ridgetown Campus, 120 Main St. East, Ridgetown, ON, N0P 2C0, CANADA. **Climate Drivers of Runoff and Phosphorus Export Through Agricultural Tile Drains Under Sandy Loams.**

Tile drains beneath agricultural fields have been identified as a key pathway for phosphorus (P) transfer. Two tile drains in an agricultural field with sandy loam soil in southern Ontario, Canada were monitored over a 28-month period to quantify discharge and concentrations and loads of dissolved reactive P (DRP) and total P (TP) in effluent. This study characterizes seasonal differences in runoff generation and P export in tile drainage and relates hydrologic and biogeochemical responses to precipitation and antecedent soil moisture conditions. Runoff in tiles was only observed above a clear threshold soil moisture content (near saturation), indicating that tile discharge responses to precipitation inputs are governed by the soil water storage capacity. Soil moisture content remained close to this threshold throughout the non-growing season (October - April), resulting in runoff responses to most precipitation inputs. Instantaneous and flow weighted mean concentrations of P in effluent were variable throughout the study but not correlated with discharge. However, there were strong relationships between discharge volume and DRP and TP loads. This research has implications for improving scientific ability to predict and model tile hydrobiogeochemical responses. *Keywords: Phosphorus, Tile drains, Lake Simcoe, Seasonality, Thresholds.*

LANE, D.[1], SOONG, R.[1], SIMPSON, A.J.[1], BERMEL, W.[2], MAAS, W.E.[3], SCHMIDT, S.[4], and HEUMANN, H.[4], [1]University of Toronto, 1265 Military Trail, Toronto, ON, M1C 1A4, CANADA; [2]Bruker BioSpin GmbH, Rheinstetten, GERMANY; [3]Bruker BioSpin Corp, 15 Fortune Drive, Billerica, MA, 01821-3991, USA; [4]Silantes GmbH, München, GERMANY. **In-vivo metabolomics: A powerful tool towards understanding real time environmental toxicity.**

Daphnia Magna are highly regarded as a keystone species because of their pivotal role in maintaining a healthy ecosystem. To date, most toxicity tests address the impact of environmental stressors using physiological endpoints such as reproduction and mortality rate. However, information regarding sub-lethal stress and toxic pathways is still desperately needed. Metabolomics has readily emerged as a powerful tool for generating comprehensive insight into sub-lethal stress. Nuclear Magnetic Spectroscopy (NMR) has become a common fixture in the field of metabolomics due to its efficacy to characterize an organisms metabolome while discerning between healthy and stressed organisms. The development of an in-vivo based approach where the organism lives inside a flow system is highly complementary to traditional studies (which use aqueous extracts or bio-fluids), as it provides the ability to deduce critical stress responses and recovery profiles to environmental contaminants in close to real time. Amino Acids are intimately tied to a multitude of stress-induced biochemical pathways. This presentation demonstrates how targeted NMR experiments can be used to recover the entire amino acids profile in-vivo in 1H-13C labelled D.magna. The approach represents a formidable tool towards understanding real-time stress processes in general. *Keywords: Bioaccumulation, Environmental policy, Isotope studies.*

LAWRENCE, P.L.[1], TURNER, V.[2], and EGAN, K.[1], [1]University of Toledo, Toledo, OH, USA; [2]Kent State University, Kent, OH, USA. **Lake Erie HABs Decision-Making Support for Maumee Watershed Stakeholders.**

As part of a suite of Lake Erie HAB research projected funded by the Ohio Department of Higher Education in 2015, this work focuses on engaging stakeholders in the Maumee watershed. This project has three connected objectives tasks: 1) development of a web based database containing key sources of available information and studies on Lake Erie

HABs including published papers, reports, websites, blogs and key agencies and contacts; 2) stakeholder network analysis intended to determine key stakeholders and connections between them, intended to assess connections and interaction among and between those interested in Lake Erie HABs; and 3) Identification of management options focused on habitat restoration opportunities within the watershed to target nutrient loading reductions including benefit-cost analysis. The aim of this work is to assist with informed decision-making by engaging Maumee stakeholders by providing them a wide diversity of high quality research and other forms of knowledge on Lake Erie HABs in order to facilitate a dialogue about the potential application of nutrient reduction methods within the watershed by use of wetlands and other habitat improvement approaches. *Keywords: Harmful algal blooms, Lake Erie, Policy making.*

LEE, K.Y.[1], YOUNG, J.[2], and XENOPOULOS, M.A.[1], [1]Trent University, 1600 West Bank Drive, Peterborough, ON, CANADA; [2]Ontario Ministry of the Environment and Climate Change, M2-22 - 900 Bay Street, Toronto, ON, CANADA. **Browning of Lake Simcoe and potential ecological consequences.**

Many northern lakes and rivers are experiencing increased colour due to augmented inputs of terrestrial material. This is known as "browning", and is usually measured as increasing dissolved organic carbon concentrations (DOC) in water. Browning has not yet been documented in large lakes. Here we use historical data from 8 stations on Lake Simcoe to discern DOC trends over the past three decades, and document related biogeochemical and ecological changes. DOC has increased from an average of 4 mg L-1 in the 1980s to 5.2 mg L-1 in the past few years. This trend is synchronous across the lake basin, suggesting that an external driver (e.g., climate, land use change) is responsible for these interannual DOC variations. To determine the nature and source of the DOC, tributary and lake waters were characterized using optical fluorescence. Initial results indicate that the DOC in Lake Simcoe is primarily allochthonous-like. Enhanced soil DOC decomposition rates driven by warming air temperatures and subsequent inputs of mineralized DOC into Lake Simcoe are possible causes of this DOC increase. Some ecological responses may be linked to the rise in DOC. Concomitant with the increase in DOC is a related decline in dissolved inorganic carbon (DIC), stabilization of secchi disk depths, and potential zooplankton community changes. *Keywords: Lake Simcoe, Organic carbon, Dissolved organic matter.*

LEGER, W.[1], MCCUNE, K.[2], SHANTZ, M.[1], and HEER, A.[2], [1]Environment and Climate Change Canada, 867 Lakeshore Road, Burlington, ON, L7S 1A1, CANADA; [2]U.S. Army Corps of Engineers, 550 Main Street, Cincinnati, OH, 3222, USA. **An Adaptive**

Management Framework for the On-Going Review of Great Lakes Water Level Regulation.

Outflows from Lake Superior and from Lake Ontario through dams on the St. Marys River and the St. Lawrence River are managed in accordance with water regulation plans issued by the International Joint Commission (IJC). Over the years, and often driven by extreme water levels, the IJC has looked at ways for improving these regulation plans. The most recent studies are the International Upper Great Lakes Study and the Lake Ontario-St. Lawrence River Study; however, the current approach of conducting a few years of study followed by long (decadal) gaps in data gathering may not be the most efficient and effective way of addressing climate changes. In early 2015, the IJC established the Great Lakes-St. Lawrence River Adaptive Management (GLAM) Committee to support the three Great Lakes Boards of Control in undertaking the required monitoring, modelling and assessment related to the on-going evaluation of the regulation plans in consideration of changing conditions. Issues to be addressed include the accuracy of and trends in water supply estimates and the on-going assessment of the impacts of changing water levels. This presentation will cover the adaptive management framework developed to help determine whether changes to regulation plans should be considered as more is learned and as conditions change over time. *Keywords: Climate change, Adaptive management, Water level fluctuations, Regulation plans, Great Lakes basin.*

LEHR, R.A.[1], VAN ROEKEL, L.P.[2], and LAFRANCOIS, T.[1], [1]Northland College, 1411 Ellis Ave, Ashland, WI, 54806, USA; [2]Los Alamos National Laboratory, Los Alamos, NM, 87545, USA. **Characterizing the magnitude and mechanism of climate change impacts in the Chequamegon Bay of Lake.**

Understanding the magnitude and mechanisms of potential climate change impacts is critical to the management of embayments throughout the Great Lakes. This research combined an observational study with an integrated modeling effort to describe the potential future water quality conditions and causative mechanisms associated with climate change impacts in the Chequamegon Bay of Lake Superior. To characterize existing conditions and validate model outputs, a suite of physical and chemical parameters were sampled bi-weekly throughout vertical profiles at eleven in-lake sites and continuously at seven tributary stations over a two-year period. Potential climate change impacts were characterized by integrating outputs from a regional hydrodynamic model (ROMS) with an aquatic response model (AQUATOX). Monitoring data suggest that water quality conditions are highly variable across both spatial and temporal scales. Similarly, model simulations suggest that the physical processes that shape water quality conditions are likely organized at different spatial scales and heavily influenced by local wind conditions. Taken together, these results suggest that changes in both water temperature and tributary loading of nutrients have the potential to impact water quality conditions in Chequamegon Bay through a diverse set of mechanisms. *Keywords: Climate change, Ecosystem modeling, Water quality.*

LEISTI, K.E., GERTZEN, E.L., TANG, R.W.K., and DOKA, S.E., Fisheries and Oceans Canada, 867 Lakeshore Rd, Burlington, ON, L7S 1A1, CANADA. **Relating Dissolved Oxygen Levels to Fish Distribution from Hydroacoustics in Hamilton Harbour.**

Summer-time hypoxia is a common occurrence in Hamilton Harbour (mean depth 13, max depth 23 m), a 245 ha embayment that is open to the western end of Lake Ontario via the Burlington shipping canal. In 2006, Fisheries and Oceans Canada (DFO) conducted seasonal fish acoustics with concurrent bottom trawling along transects at 6, 10, 15 and 20 m depth contours. Temperature and oxygen profiles were measured at the start of each transect and the frequency that DO levels fell below 5 mg/l was 5.2% in the spring, 37.6% in the summer and 3.6% in the fall. This presentation will examine spatial relationships between fish distribution and dissolved oxygen levels from July 24 to Aug 4. An update to the 2006 fish acoustics and trawling survey is planned for 2016 and will compliment the fish telemetry study that began in 2015. *Keywords: Hamilton Harbour, Acoustics, Fish.*

LEKKI, J.[1], ANDERSON, R.[1], AVOURIS, D.[2], BECKER, R.H.[3], CLINE, M.T.[3], LESHKEVICH, G.[4], LIOU, L.[1], LUVALL, J.C.[5], ORTIZ, J.D.[2], RUBERG, S.A.[4], SAWTELL, R.[6], SAYERS, M.[6], SCHILLER, S.[9], SHUCHMAN, R.A.[6], SIMIC, A.[7], STUART, D.G.[8], TOKARS, R.[1], and VANDER WOUDE, A.J.[8], [1]NASA Glenn Research Center, 21000 Brookpark Rd., Cleveland, OH, 44135, USA; [2]Kent State University, Kent, OH, USA; [3]University of Toledo, Toledo, OH, USA; [4]NOAA Great Lakes Environmental Research Lab, Ann Arbor, MI, USA; [5]NASA Marshall Space Flight Center, Huntsville, AL, USA; [6]Michigan Technological Research Institute, Ann Arbor, MI, USA; [7]Bowling Green State University, Bowling Green, OH, USA; [8]University of Michigan, Ann Arbor, MI, USA; [9]South Dakota State University, Brookings, SD, USA. **Airborne Hyperspectral Imaging for monitoring Harmful Algal Blooms in the Great Lakes region.**

Since 2006 researchers from NASA John H. Glenn Research Center (GRC) have collaborated with scientists from NOAA and Universities on developing hyperspectral remote sensing for monitoring Harmful Algal Blooms (HABs) in optically complex waters, such as occur in the western basin of Lake Erie. The scale of the effort elevated in 2014 and further in 2015 as a result of the Toledo municipal water shutdown due to algal toxin found at the city's water intake in Lake Erie. Since then, GRC has carried on an expanded numbers of flights using its aircraft, equipped with a Hyperspectral Imager (HSI), to monitor algal bloom intensity and distribution in Lake Erie, inland lakes and the Ohio River. While the

HAB monitoring information has been helpful to water resource managers, the effort has also focused on research towards improving the remote sensing capability. An extensive data set has been gathered that includes collocated remote sensing data, water samples and in situ optical measurements. This data set is being used to rigorously validate the HSI for future, broader applications in water quality. It is also being used for research into improved remote sensing atmospheric correction over water and towards new algorithms to delineate potentially harmful algal blooms from nuisance blooms and determine their concentrations.
Keywords: Remote sensing, Harmful algal blooms, Observing systems.

LEMBCKE, D. and ASPDEN, L., Lake Simcoe Region Conservation Authority, 120 Bayview PArkway, Newmarket, On, L3Y4X1, CANADA. **Can we Implement Environmental Flows in a catchment not experiencing low flow stress?**

The application of Environmental Flows to river management has required a paradigm shift away from the exclusive use of low flow thresholds to target regimes that recognize the importance of managing a river for a wide range of flows. While this is a huge step forward, the majority of work in Environmental Flows has focused on rivers where the initial stressor is to low flows. Indeed the vast majority of implementation tools to date involve changes to dam management or water taking. Rarely has the Environmental Flow concept been applied to rivers that do not have a low flow stress but instead see impacts to the mid-flow regime. Lovers Creek in the Lake Simcoe Watershed (Ontario, Canada) is experiencing impacts related to land use change. For the purposes of developing and implementing an Environmental Flow regime the catchment was modelled under three land use states. The results of the modelling show that the land use change that has occurred is not causing detrimental impacts to baseflow but instead are causing impacts to high pulse flows. Implementation of an Environmental Flow regime must therefore focus on mitigating the changes to these high pulse flows, an area where the existing body of Environmental Flow work has traditionally not focused on, nor developed tools for implementation.
Keywords: Lake Simcoe, Environmental Flows, Ecosystem health, Remediation.

LENARDUZZI, A.L., Credit Valley Conservation, 1255 Old Derry Road, Mississauga, ON, L5N 6R4, CANADA. **A Decision Support Tool for Sustainable Water Management and Planning.**

The water infrastructure deficit across Ontario is estimated to be $100 billion (60% of the national deficit). A cost effective approach to water, wastewater and stormwater management is needed as climate change is predicted to increase risk to our communities. The development of a decision support tool, which considers the interconnections between

drinking water, stormwater, wastewater, and natural water systems, can provide a comprehensive understanding of risks and costs associated with water management and planning decisions. This tool reveals how weather events interact with constructed and natural water infrastructure to result in positive and negative impacts on the environment, and on human health and well-being. The tool incorporates the increased risks associated with climate change, and the cost associated with mitigating those risks, to provide decision-makers with a complete picture to make efficient investments in water management.
Keywords: Climate change, Decision making, Risk assessment.

LENTERS, J.D.[1], READ, J.S.[2], SHARMA, S.[3], O'REILLY, C.M.[4], HAMPTON, S.E.[5], GRAY, D.K.[6], MCINTYRE, P.B.[7], HOOK, S.J.[8], SCHNEIDER, P.[9], and COLLABORATION, G.L.T.[1], [1]LimnoTech, Ann Arbor, USA; [2]USGS, Middleton, USA; [3]York University, Toronto, USA; [4]Illinois State University, Normal, USA; [5]Washington State University, Pullman, USA; [6]California University of Pennsylvania, California, USA; [7]University of Wisconsin-Madison, Madison, USA; [8]NASA Jet Propulsion Laboratory, Pasadena, USA; [9]Norwegian Institute for Air Research, Kjeller, USA. **Long-term warming of the world's large lakes: Results from the Global Lake Temperature Collaboration.**

Recent studies have shown significant warming of inland water bodies around the world. To better understand the patterns, mechanisms, and ecological implications of global warming of lakes and reservoirs, the "Global Lake Temperature Collaboration" (GLTC) was started in 2010 to compile and analyze lake temperature data from in situ and satellite-based records dating back at least 20-30 years. The GLTC project has now assembled data from over 250 lakes, with some records dating back more than 100 years. Here, we present an analysis of the long-term warming trends, interdecadal variability, and a direct comparison between in situ and remotely sensed summer lake surface temperatures. The results show consistent trends of lake surface warming across most but not all sites. A few hotspots of warming are identified around the world, including the Laurentian Great Lakes, northern Europe, and southwest United States. Almost half of the world's lake surfaces are warming at rates in excess of 0.5 °C per decade during the period 1985-2009, and a few even exceed 1.0 °C per decade. This is particularly true for a number of the world's large, deep lakes, and we discuss some of the mechanisms responsible for this rather counterintuitive result.
Keywords: Climate change, Water temperature, Global warming, Remote sensing.

LENTERS, J.D.[1], BLANKEN, P.D.[2], SPENCE, C.[3], RUCINSKI, D.K.[1], BROOKS, C.N.[4], and GIBBONS, E.H.[5], [1]LimnoTech, Ann Arbor, USA; [2]University of Colorado-Boulder, Boulder, USA; [3]Environment and Climate Change Canada, Saskatoon, USA; [4]Michigan Tech Research Institute, Ann Arbor, USA; [5]Great Lakes Integrated Sciences + Assessments

(GLISA), Ann Arbor, USA. **Predicting Lake Superior stratification dates and surface temperature following the 2015-16 El Niño.**

The 2015-16 winter witnessed one of the strongest El Niño events in modern history. In the Great Lakes region, El Niño winters are typically very warm, with below-normal ice cover on the Great Lakes, followed by warm summer water temperatures and above-normal evaporation rates. This past winter was no exception, with above-normal air and water temperatures in the fall and early winter of 2015 and less than 9% total ice coverage on the Great Lakes in late January. The strongest previous El Niño occurred in 1997-98 and was associated with a regime shift in Lake Superior ice cover, water temperature, and evaporation. In the interest of improving our ability to forecast the impacts of such extreme climatic events, we have developed a simple but informative tool for Lake Superior known as the Seasonal LAke Temperature Energetics (SLATE) model. SLATE predicts the onset date of summer stratification as a function of local water depth, as well as seasonal variations in summer lake surface temperature (LST). The SLATE model has been previously tested and validated against buoy-based and remotely sensed LST data, including case studies of the warm and cold summers of 2010 and 2014, respectively. Here, we present an overview of the SLATE model and a forecast of the impacts of the recent El Niño on summer conditions in Lake Superior. *Keywords: El Niño, Water temperature, Climate change, Air-water interfaces.*

LEPAK, R.L.[1], YIN, R.[1], KRABBENHOFT, D.P.[2], HOLSEN, T.M.[3], and HURLEY, J.P.[4], [1]University of Wisconsin-Madison, Environmental Chemistry and Technology Program, 660 North Park Street, Madison, WI, 53706, USA; [2]United States Geological Survey, Wisconsin Water Science Center, 8505 Research Way, Middleton, WI, 53562, USA; [3]Clarkson University, Potsdam, NY, 13699, USA; [4]University of Wisconsin Aquatic Sciences Center, 1975 Willow Drive, Madison, WI, 53706, USA. **Utilizing Hg Stable Isotope Ratios to More Fully Resolve Hg Processes and Sources in the Great Lakes.**

A recent study using Hg stable isotopes revealed the three primary contributors of Hg to Great Lakes sediment: atmospheric, watershed derived, and industrial. The results of an isotopic mixing model, based on mass-dependent (MDF) and mass-independent fractionation (MIF), provided evidence of the sources of Hg to surface sediments of each lake. In addition, anomalous even MIF, found in sediment, was used to independently confirm the primary model presented. Research suggests both that even MIF is conserved during biogeochemical processing and odd MIF is conserved during metabolic processing. It is reasonable to suspect that even MIF is similarly conserved through metabolism. Preliminary data suggests even MIF may be used as an indicator of atmospheric sources of Hg bioaccumulated at higher trophic levels. We are expanding our isotopic analyses to

include lake trout samples collected over time in the Great Lakes to assess Hg isotopes as biological tracers, as well as to confirm even MIF presence through various trophic levels in the Great Lakes. We aim to show which physicochemical and photochemical controls are important in Hg signatures. Use of isotopic Hg signatures for natural resource management and restoration decisions requires detailed understanding of the key transport and transformation processes in lacustrine systems. *Keywords: Stable isotopes, Bioaccumulation, Great Lakes basin, Lake Trout, Mercury.*

LESHKEVICH, G.[1], SHUCHMAN, R.A.[2], and NGHIEM, S.V.[3], [1]NOAA/Great Lakes Environmental Research Laboratory, 4840 South State Rd., Ann Arbor, MI, 48108, USA; [2]Michigan Tech Research Institute, 3600 Green Court, Suite 100, Ann Arbor, MI, 48105, USA; [3]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA, 91109, USA. **Light Transmittance Through Ice and Snow Cover on the Great Lakes.**

Primary productivity in the Great Lakes is reduced in the winter months owing to light attenuation by ice and snow cover on the lakes. To quantify the attenuation effects of ice and snow cover, a series of radiometric measurements in the 400-700 nm Photosynthetically Active Radiation (PAR) spectral range were made for several ice types at different locations on the Great Lakes as well as a number of smaller inland freshwater lakes during the winters of 2015 and 2016. The PAR irradiance measurements were made using a calibrated Analytical Spectral Device (ASD) ViewSpec 3 with an underwater Remote Cosine Receptor. Initial irradiance measurements were taken at the surface above the ice, then the unit was submerged and measurements were taken at the water/ice interface and at depths up to a meter. The percent light transmitted through ice varied greatly from snow covered ice to clear lake ice. Once average light attenuation measurements are obtained for major Great Lakes ice types (as in the SAR backscatter library), they can be used with maps of satellite SAR classification of ice types and maps of ice concentration to assess, to first order, the seasonal lake-wide effect of ice and snow cover on light transmittance. *Keywords: Remote sensing, Light transmittance, Ice, Satellite technology.*

LI, W., MORRISON, S., and JOHNSTON, J.W., Department of Earth and Environmental Science and Water Institute, University of Waterloo, 200 University Ave. West, Waterloo, ON, N2L 3G1, CANADA. **Evaluating Trends and Pattern of Glacial Isostatic Adjustment Near Lake Superior.**

The motion of ground beneath and adjacent to Lake Superior (LS) continues being influenced by the long-gone Laurentian Ice Sheet (LIC). The rate and pattern of vertical ground movement, glacial isostatic adjustment (GIA), is related to many factors including variations in ice thickness and duration during the retreat of LIC. Many previous studies have recorded data of GIA by various methods, but the accuracy and consistency of these data is unknown considering the different time periods examined by different projects. Hence, these data need to be analyzed and compiled to provide one view of GIA near LS. Here we present data collected from GPS, lake level gauges and ancient shorelines. Published rates of GIA from GPS stations surrounding LS were selected from a dataset covering North America spanning recent decades. Water level gauge data for LS extended many decades before GPS data was updated from 2006 and reanalyzed following methods used in the newest International Upper Great Lakes Study. Comparison between ancient shorelines of beach ridges adjacent to LS was analyzed in regard of GIA over several millennia. After each source was analyzed independently, they were then compared between one another and with previously published data. A new compiled rate and pattern of GIA near LS is generated and presented here. *Keywords: Deglaciation, Glacial isostatic adjustment(GIA), Lake Superior, Data storage and retrieval.*

LI, Y., BENCE, J.R., and BRENDEN, T.O., Department of Fisheries and Wildlife, Michigan State University, 13 Natural resources Building, East Lansing, MI, 48824, USA. **Bayesian variable selection for the determination of factors related to fish movement distance.**

We explored which factors influence lake whitefish to move for greater distances, based on the 2003-2011 tagging research of lake whitefish in Lake Huron. Like many tagging studies, fish were tagged on spawning grounds and then recovered(dead) during the fishing season. Lake whitefish in Lake Huron have been found to move among multiple management units during non-spawning period with natal homing. We conduct a variable selection procedure under Bayesian framework to explore the top regression models and top factors that are favored by the data, and assess the associated uncertainty. The Bayesian variable selection procedure examined general hypotheses for how life history traits (i.e., total length, and sex), temporal scales (i.e., tagging year, recovery year and month, and year(s) between tagging and recovery), and habitat conditions (i.e., relative *Diporeia* density and growing degree-days) combine to influence movement distance. The Bayesian variable selection treats the regression model itself as random in the model space that comprises of all possible models with different sets of variables, and hence is more powerful in assessing the uncertainty. The implementation via the reversible jump Markov Chain Monte Carlo is greatly more efficient in exploring the model space than traditional approaches.
Keywords: Bayesian variable selection, Lake whitefish, Movement distance.

LIAGHATI MOBARHAN, Y.[1], FORTIER-MCGILL, B.[1], SOONG, R.[1], MAAS, W.E.[2], FEY, M.[2], MONETTE, M.[3], STRONKS, H.J.[3], SCHMIDT, S.[4], HEUMANN, H.[4], NORWOOD, W.[5], and SIMPSON, A.J.[1], [1]Department of Physical and Environmental Science, University of Toronto, 1265 Military Trail, Toronto, ON, M1C 1A4, CANADA; [2]Bruker BioSpin Corp.,, 15 Fortune Drive, Billerica,, MA, 01821-3991, USA; [3]Bruker BioSpin Canada, 555 Steeles Avenue East, Milton, ON, L9T 1Y6, CANADA; [4]Silantes GmbH, Gollierstr. 70 C, München, 80339, GERMANY; [5]Environment Canada, 867 Lakeshore Rd., Burlington, ON, L7R 4A6, CANADA. **Comprehensive Multi-Phase *In-vivo* NMR Spectroscopy.**

An organism is a synergy of different phases; metabolites provide an information-rich molecular fingerprint that help to explain biochemical fluxes induced by environmental stressors. Similarly, gels (i.e. proteins) and solids (i.e. shells) hold the potential to elucidate changes to the structural framework of a living system. NMR spectroscopy is one of the most powerful tools in modern science and can provide unprecedented information as to molecular structure and interactions, however traditionally samples had to be changed (dried for solids, extracted for liquids) for analysis. Comprehensive Multiphase (CMP) NMR is a novel technology with the unique ability to study all these phases in an intact sample, using a single NMR probe. Here, HR-MAS CMP NMR is applied to a living organism for the first time, the research shows all components in the model organism, *H. azteca* (commonly used in aquatic and sediment toxicity testing) can be observed. When all phases are considered together, CMP-NMR provides a unique window into the living molecular world with the potential to reveal the structures, associations and interactions that synergistically give rise to life. CMP-NMR represents a powerful complimentary tool to study real-time environmental stress. *Keywords: Environmental contaminants, Chemical analysis, Metabolism.*

LIN, H., URBAN, N.R., and PERLINGER, J.A., Michigan Technological University, 1400 Townsend Drive, Houghton, MI, 49931, USA. **Spatial and Temporal Variability in PCB Levels in Lake Trout (Salvelinus namaycush) in Lake Superior.**

It is frequently reported that PCB concentrations in Great Lakes fish have declined rapidly since the production ban in 1979 although some studies suggest that recent rates of decline are slowing. We analyzed fish contaminant data from the US EPA and Michigan Department of Environmental Quality (MDEQ) and performed multiple linear regression analyses to examine spatial and temporal variability in PCB levels in lake trout from Lake Superior. Because of a change in analytical methodology, it is not possible to analyze the whole period of record for the EPA data; the MDEQ analyzed fish by both methods for two years so early data can be corrected to be comparable to later data. The PCB levels in lake trout (Salvelinus namaycush) from Lake Superior vary among sample sites, possibly a result of different food webs within the lake. For Keweenaw Point, PCB concentrations

were positively correlated with fish size and negatively correlated with time for the period 1995-2009. In contrast, no statistically significant relationship was found between PCB levels and time during the same period for fish from the Apostle Islands or Keweenaw Bay area although a positive correlation with fish size still existed. *Keywords: Lake trout, PCBs, Lake Superior.*

LIN, S.Q.[1], VALIPOUR, R.[1], ZHAO, Y.M.[2], and BOEGMAN, L.[1], [1]Queen's University, Kingston, ON, K7L1N6, CANADA; [2]Ontario Ministry of Natural Resources and Fisheries, Peterborough, ON, K9J 8M5, CANADA. **Sediment resuspension modeling in Lake Erie.**

Sediments play an important role in elemental cycling in the aquatic environment. Sediment resuspension contributes to total suspended solids (TSS), especially in shallow lakes like Lake Erie, and impacts water quality, with biological and chemical processes in Lake Erie being closely related to resuspension events. Using the three-dimensional hydrodynamic biogeochemical model ELCOM-CAEDYM, we simulate the sediment resuspension events throughout Lake Erie during April to October 2008. ELCOM has shown ability in capturing the temperature, and basin-scale wave-induced currents in Lake Erie. We evaluate the ability of ELCOM-CAEDYM to parameterize the steady currents and oscillatory surface wave currents that cause bottom shear stress and ultimately sediment resuspension events. The model results are compared with satellite images and observed field data, consisting of moored current profilers and turbidity loggers, as well as profiles of measured TSS, during 2008. *Keywords: Sediment resuspension, Lake Erie, Modeling.*

LINARES, A., BECHLE, A.J., and WU, C.H., UW-Madison, Engineering drive 1410, Madison, WI, 53703, USA. **Characterizing and forecasting meteotsunami hazards in northern Lake Michigan.**

Meteotsunamis are tsunami-like waves induced by moving atmospheric perturbations of air pressure and wind. Meteotsunamis with large amplitudes have caused a great deal of fatalities and property losses in Lake Michigan, thus posing considerable hazards to coastal communities. In this talk, we will examine the meteotsunamis in northern Lake Michigan including Manistique River Bay and Port Inland during the past 10 years in order to characterize meteotsunami hazards. In particular, we examined the relationship between meteorological and water level data to quantify the weighting of wind and air pressure on meteotsunami generation. Results show that wind and pressure have a similar weighting in northern Lake Michigan. Additionally, pressure driven meteotsunamis tend to be associated with convective storms, whereas wind driven meteotsunamis are usually associated with frontal storms. Hydrodynamic modeling is used to assess the sensitivity of meteotsunami wave height to the storm speed and direction. Interestingly, meteotsunamis in northern Lake Michigan are most commonly caused by storms traveling with an eastward component whereas the hydrodynamic model shows northward moving storms as the most hazardous. Based on this analysis, a new and efficient methodology is developed to forecast rapid moving meteotsunamis for timely warning. *Keywords: Atmosphere-lake interaction, Meteotsunami forecast, Coastal processes, Lake Michigan.*

LIU, S.[1] and LESHKEVICH, G.[2], [1]Cooperative Institute for Limnology and Ecosystem Resaech, 4840 South State Rd., Ann Arbor, MI, 48108, USA; [2]NOAA/Great Lakes Environmental Research Laboratory, 4840 South State Rd., Ann Arbor, MI, 48108, USA. **CoastWatch - Delivering Environmental Satellite and In Situ Data to the Great Lakes User Community.**

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 (http://coastwatch.glerl.noaa.gov). Utilities such as JAVA GIS and Google Earth® allow interactive retrieval of physical parameters such as surface temperature, ice cover, and surface winds at a given location. Future products include chlorophyll, DOC, suspended mineral, HABs, upwellings, and new data sets such as Great Lakes Optical Properties Geospatial Database (GLOPGD), and long-term surface water temperatures in ascii gridded format. A new CoastWatch server running THREDDS (Thematic Real-time Environmental Distributed Data Services) for accessing and publishing scientific data in a convenient fashion will soon be available. *Keywords: Remote sensing, Satellite technology, Great Lakes basin.*

LIU, Y. and YANG, W., University of Guelph, 50 Stone Road East, Guelph, On, N1G2W1, CANADA. **Place-based Modelling for Assessing Water Quantity Effects of BMPs under Climate Change.**

In this study, a place-based hydrologic model, imWEBs (Integrated Modeling for Watershed Evaluation of BMPs), is applied to the 15-km2 Gully Creek watershed in the Lake Huron Basin, which is one of the study site for OMAFRA's Watershed-Based BMP

Evaluation (WBBE) program during 2010-2013. The purpose of the project is to examine water quantity effects of agricultural management practices under climate change and adaptation options at field scale. The hourly imWEBs model is setup, calibrated, and applied to examine water quantity effects of agricultural management practices including cover crop, nutrient management, and conservation tillage under different climate change and adaptation scenarios. The results are assessed at both field and watershed outlet to analyze the impact of adaptation options on flow and sediment under climate change conditions. In comparing to widely used Soil and Water Assessment Tool (SWAT) developed by U.S. Department of Agriculture, the place-based modelling tool has the advantage of characterizing agricultural landscapes at cell/location level, simulating hydrologic processes at both daily and hourly time step, and integrating easily with economic and ecologic models. It is expected that this type of model will play an effective role in soil and water conservation programs.
Keywords: Modeling, Management, Climate change.

LOFGREN, B.M.[1], GRONEWOLD, A.D.[1], XIAO, C.[2], PEI, L.[3], CHARUSOMBAT, U.[4], and CHU, P.[1], [1]NOAA/Great Lakes Environmental Research Laboratory, 4840 S. State Rd., Ann Arbor, MI, 48108, USA; [2]Cooperative Institute for Limnology and Ecosystems Research, U. of Michigan, 4840 S. State Rd., Ann Arbor, MI, 48108, USA; [3]University Corporation for Atmospheric Research, c/o NOAA/GLERL, 4840 S. State Rd., Ann Arbor, MI, 48108, USA; [4]National Research Council Fellow Program, c/o NOAA/GLERL, 4840 S. State Rd., Ann Arbor, MI, 48108, USA. **WRF-Hydro and Atmosphere-Land Coupled Modeling at NOAA - GLERL.**

Systems for simulation of coupled atmospheric and hydrologic systems are advancing nationally and internationally, creating a need for scientists in the Great Lakes region to interact with efforts that are larger both in terms of geography and institutional involvement. One of our primary efforts in this area is use of the Weather Research and Forecasting (WRF) Model and its companion hydrologic model (WRF-Hydro) in both one-way and two-way coupled modes with application specifically to the Great Lakes basin. This dovetails with existing work on multi-decadal climate modeling using WRF and will coordinate with broader NOAA efforts on water resources forecasting at weather timescales (2 weeks and less), especially to incorporate the Canadian portion of the basin into the forecast system. Some possible model configurations include multi-decadal simulation with the WRF atmosphere driven at its lateral boundaries by a global model and two-way coupled to WRF-Hydro, or WRF-Hydro driven directly by a high-resolution atmospheric reanalysis product. While atmospheric processes are typically depicted at grid spacings around 25-50 km, hydrological processes can be simulated at finer resolution. We will present demonstration and validation of WRF-Hydro simulations on seasonal to decadal time scales and various coupling configurations. *Keywords: Water resources prediction, Atmosphere-surface interaction, Hydrologic budget.*

LOZIER, T.M. and MACRAE, M.L., University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L 3G1, CANADA. **Hydroclimatic Influences on Potential Phosphorus Mobilization from Crop Residue and Cover Crops.**

Maintaining crop residue or cover crops on fields is increasingly being promoted as a best management practice for environmental sustainability. However, vegetation exposed to freeze-thaw cycles (FTC) can enhance dissolved reactive phosphorus (DRP) losses in runoff. Most studies of winter DRP loss from plants have been conducted in colder climates or experimentally with larger temperature fluctuations than experienced in the Great Lakes Region (GLR), clouding our understanding of cover crop efficacy for P management in the GLR. We used a factorial design experiment to determine the effects of FTC (-4°C to 4°C) and moisture addition (water extractable P, ponding, rainfall) on DRP leaching from Triticum aestivum (Winter wheat stubble), Trifolium pretense (Red Clover) and Avena sativa (Oats). Both cover crops released more P than winter wheat stubble. Increased DRP loss from oats occurred following FTC, but not from clover or wheat stubble. Surface ponding lead to greater and more immediate DRP loss relative to a series of simulated rainfall events. This study provides insight into the combined impacts of FTC, vegetation type and event type on winter DRP loss, which may allow managers to optimize the use of cover crops for P management in the GLR. *Keywords: Phosphorus, Freeze-thaw cycles, Cover crops, Crop residue.*

LU, J.[1], STRUEWING, I.[2], ALLEN, J.[1], CHEN, K.[3], TETTENHORST, D.R.[1], and SHOEMAKER, J.[1], [1]1ORD, U.S. EPA,, 26W Martin Luther King Dr., Cincinnati, OH, 45268, USA; [2]2Dynamac Inc, 26W Martin Luther King Dr., Cincinnati, OH, 45268, USA; [3]Southwest University of Science and Technology, Mianyang, USA. **qPCR and RT-qPCR of Harmful Cyanobacteria at Lake Harsha, OH, during Summer.**

Toxic cyanobacteria from the water samples of five sites in Lake Harsha, which is used for local recreational activities and as a source of drinking water, were detected using a panel of qPCR assays for most of toxin-producers (HEP and CD1) or only toxic Microcystis spp. (mcyG and mcyA-MS) targeting the toxin-producing genes of mcyA, mcyE, ndaF and mcyG. Overall performance of the four assays were highly correlated with each other for DNA along weekly and daily samples, indicating similar level of copy numbers and amplification efficiency of the targeted genes. The quantity of total toxic cyanobacteria reached 100 million cell/L in early June and remained at high density until the end of July. During this period, the signals of qPCR between HEP and mcyG or mcyA-MS were in

agreement, and demonstrated that Microcystis spp. dominated the toxin producers. Before and after the peak period, approximately only half of Microcystis spp. accounted for the total toxin producers. RT-qPCR results showed the same trend as qPCR, but with higher variations in assays for Microcystis spp., indicating potential toxins were produced mainly by Microcystis spp. Generally much lower signals of qPCR and RT-qPCR were detected from deep water than surface water suggesting that the majority of toxins were generated from surface water. *Keywords: Algae, QPCR, Molecular.*

LUTSKY, K.O. and BURKHOLDER, S.L., University at Buffalo - SUNY, 114 Diefendorf Hall, Buffalo, NY, 14214, USA. **EXTRA: situating a place for 'time' within the littoral Great Lakes.**

Due to recent water level fluctuations, the land associated with the edge conditions of the Great Lakes is shifting by way of dredging regimes and newly emerged and submerged terrain along shallow shores. The once tightly situated definition between developed land and water is slowly opening up, exposing new uncharted areas. The majority of these conditions take place within the populated, agrarian bays of the Basin. These shallow bays, many former lakebeds, are now the sites of the most evident products of climate change, population growth and wetland loss. Using a collection of these bays, this talk will discuss the design potential of this new territory, or as we call it, 'EXTRA", to establish an approach to coastal occupation that leverages the dynamics of an ecological time scale as opposed to a solely anthropological one. It will explore how physical (e.g. access, function) and political (e.g. ownership and control) interventions within 'EXTRA' littoral zone might prioritize more tempro-territorializing ecologically-calibrated agendas that stress performance and adaptability as design agents while addressing issues such as management, accountability, and public perception. *Keywords: Littoral zone, Management, Urbanization.*

M

MAAVARA, T., SLOWINSKI, S., REZANEZHAD, F., and VAN CAPPELLEN, P., Ecohydrology Research Group, University of Waterloo, 200 University Ave W, Waterloo, ON, N2L 3G1, CANADA. **Nutrient Stoichiometry in the Grand River Watershed: The Role of Groundwater Silicon.**

Nutrient silicon (Si) limited systems tend to promote more harmful algal blooms, compared with phosphorus (P) or nitrogen (N) limited systems. In this project, we studied the biogeochemical sources and sinks of Si in the Grand River watershed (GRW), a 7000 km^2 basin located in the largely agricultural region of southwestern Ontario, Canada. The river, its major tributaries, and eastern Lake Erie, into which the GRW drains, have historically been considered P limited. We collected groundwater and surface water samples at 11 locations in the lower half of the GRW at weekly to monthly intervals for one year. Samples were analyzed for dissolved and reactive particulate Si (DSi and PRSi), total dissolved P, soluble reactive P, and a suite of other macro and micronutrients. Results indicate that groundwater discharge to surface water provides a year-round source of DSi to surface water, with concentrations roughly equal to winter surface water concentrations. In winter, up to 85% of the Si delivered to Lake Erie from the GRW is from groundwater in the study region. Si limitation occurs nearly as often as P limitation in regions where groundwater discharge is low. In regions with high groundwater discharge, Si limitation is temporally restricted to the spring snowmelt and the subsequent spring peak in diatom biomass. *Keywords: Biogeochemistry, Silicon, Grand River.*

MACDONALD, J.L.[1], SCHOEN, L.S.[2], STUDENT, J.J.[3], and UZARSKI, D.G.[1], [1]Institute for Great Lakes Research, Mt. Pleasant, MI, 48859, USA; [2]MI Department of Environmental Quality, Lansing, MI, USA; [3]Central Michigan University, Department of Earth and Atmospheric Sciences, Mt. Pleasant, MI, 48859, USA. **Variation in Yellow Perch (*Perca flavescens*) Growth Rate in the Great Lakes.**

Yellow perch (*Perca flavescens*) are one of the most important fish to the Great Lakes ecologically and economically, but their numbers have been declining over the past decades. Research has verified the existence of wetland and nearshore resident yellow perch; however, the influence that habitat use may have on morphological characteristics has not been completely addressed. We examined the influence of wetland and nearshore residency on yellow perch morphometry in Lake Michigan. Twenty-two morphometric measurements and five meristic counts were taken for 222 yellow perch which were then aged using otoliths. Based upon the results of previous studies, we anticipated that wetland residents have different morphometries than nearshore residents. A multivariate analysis of covariance (MANCOVA) was run to determine the significance that location had upon the morphometry of resident fish, while a principal components analysis (PCA) was run to determine which morphological characteristics were most different between wetland and nearshore contingents. It was found that there is a significant difference between wetland and nearshore residents, with nearshore residents being, on average, longer than their wetland counterparts. *Keywords: Lake Michigan, Morphometrics, Yellow perch.*

MACKAY, S.E., SCOTT, H., and KIRKWOOD, A.E., University of Ontario Institute of Technology, 2000 Simcoe St.N., Oshawa, ON, L1H7K4, CANADA. **Resident Attitudes, Perceptions and Practices regarding Fertilizer Use in the Lake Simcoe Watershed.**

It has been estimated that 31% of phosphorus loading in the Lake Simcoe watershed (LSW) originates from urban stormwater and runoff. A major contributor to stormwater nutrients is cosmetic fertilizer from residential lawns and gardens. To understand the underlying behavior motivating fertilizer application, we developed a community survey through LimeSurvey to ask respondents about their environmental attitudes and lawn-care/fertilizer choices, in addition to demographic parameters. The survey was administered to residents in the LSW during the winter of 2016. Survey results will be compared to studies from other regions, which found that 25% - 50% of respondents fertilize, and half of them use chemical fertilizer. It is anticipated that residents who fertilize will fertilize because of normative pressure from neighbours and, despite knowing the environmental impacts, would continue to fertilize. In addition to documenting residential attitudes about cosmetic fertilizer use, data from our survey will be used to estimate fertilizer application quantity and frequency. These results will help to fill knowledge gaps in our understanding of non-agricultural nutrient loadings in the LSW as well as inform recommendations for best management practices and education outreach in the region. *Keywords: Lake Simcoe, Fertilizer, Public participation, Community survey, Pollution sources, Environmental attitudes.*

MAGUFFEE, A.C., JONES, M.L., CLARK, R.D., and REILLY, R., Quantitative Fisheries Center, Department of Fisheries and Wildlife, Michigan State University, 293 Farm Lane - Room 153, Giltner Hall, East Lansing, MI, 48824, USA. **Evaluating Differences in Otolith Chemistry of Lake Michigan Chinook Salmon to Identify Natal Origin.**

An increasing amount of uncertainty about Lake Michigan Chinook salmon (*Oncorhynchus tshawytscha*) recruitment dynamics has followed the 2004 Lake Huron alewife collapse. Increased uncertainty regarding recruitment may be attributed to the migration of juvenile Chinook salmon from Lake Huron to Lake Michigan, perhaps due to greater foraging opportunities in Lake Michigan where alewife numbers remain relatively large. Otolith microchemistry has been used successfully to determine region of origin for other introduced Great Lakes salmonids, suggesting its potential for use with Lake Michigan Chinook salmon. This study aims to assess whether, and to what extent, Chinook salmon from Lake Huron contribute to the harvested population in Lake Michigan. Chinook salmon otolith pairs were extracted from 299 juveniles and 155 adults, collected from streams in six predefined regions as well as a hatchery group. Otoliths were analyzed using Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICPMS) to determine trace metal concentrations, and a MANOVA was used to test for chemical differences. The

concentration data was used to develop classification models using statistical methods and machine learning algorithms. We expect to use these models to determine the origins of unknown-source fish harvested in Lake Michigan. *Keywords: Lake Michigan, Otolith, Salmon, Microchemistry.*

MAHON, A.R., Institute for Great Lakes Research, Dept. of Biology, Central Michigan University, Mount Pleasant, MI, 48859, USA. **Using Active and Passive Molecular Tools for Surveillance in Aquatic Environments.**

From its inception in large scale monitoring applications, environmental DNA (eDNA) has been a useful delimiting tool for analyzing species presence and ranges in aquatic systems. With these methods, water samples are screened for the presence of DNA from a targeted species. However, with every water sample collected, DNA from many species is collected. The field of eDNA surveillance has moved from using strictly active surveillance methods such as standard PCR to more quantitative methods (qPCR, ddPCR, etc.) for single species screening. Additionally, newly developed high-throughput (also termed next generation) sequencing approaches allow for more passive surveillance where a community of species is identified. Depending on the research question, active surveillance may be more sensitive to detecting rare DNA, however passive surveillance has the capability of detecting unexpected invasive species. Case studies for both of these scenarios will be discussed. Additionally, this presentation will cover the development of environmental DNA tools as they apply to both active and passive surveillance in aquatic systems throughout the Great Lakes basin and beyond. *Keywords: Biodiversity, Invasive species, Environmental DNA, Genetics.*

MAJARREIS, J.M.[1], BOEGMAN, L.[2], HIRIART-BAER, V.[3], HOWELL, E.T.[4], DEPEW, D.[3], and SMITH, R.E.H.[1], [1]University of Waterloo, 200 University Ave. W., Waterloo, ON, N2L 3G1, CANADA; [2]Queen's University, 99 University Ave., Kingston, ON, K7L 3N6, CANADA; [3]Canada Centre for Inland Waters, 867 Lakeshore Rd, Burlington, ON, L7S 1A1, CANADA; [4]Ontario Ministry of the Environment and Climate Change, 125 Resources Rd., Toronto, ON, M9P3V6, CANADA. **Dissipation of TKE and implications for phosphorus fluxes in the nearshore of East Basin, Lake Erie.**

The benthic alga Cladophora has been reaching nuisance levels in the nearshore zone of East Basin Lake Erie. Its biomass has been positively correlated with available phosphate. Possible sources of phosphorus include tributaries and mussel excretion. Physical processes, especially in the near-bed, may influence the distribution of this important nutrient. Water movements influence the buildup or abolishment of near-bed phosphate gradients and determine whether particulate phosphorus can be re-suspended. An Aquatic Doppler

Current Profiler (ADCP) was deployed at a 10m station in down-looking mode for 8h, collecting measurements every 15 minutes. Concurrently, modified Hesslein samplers ("peepers") passively sampled near-bottom gradients of phosphate and ammonium. The structure function method was used to calculate dissipation. Near-bed temperature and the concentration gradient were used to calculate diffusive flux. Results appear to be meaningful in understanding Cladophora nuisance growth. This is one of the first studies to directly measure gradients of mixing energy and phosphate to estimate flux, which can help improve predictive management models. *Keywords: Bottom currents, Cladophora, Phosphorus.*

MALINICH, T.D. and HÖÖK, T.O., Purdue University, 195 Marstellar Street, West Lafayette, IN, 47907, USA. **Yellow Perch as a Model for Understanding Morphological Plasticity and Phenotypic Diversity.**

Various studies in the Laurentian Great Lakes have documented morphological variation within and among populations of yellow perch, *Perca flavescens*. Morphological expression for these fish appear to be related to environmental conditions, but it is unclear if expression is adaptive and genetically-controlled or if, similar to Eurasian perch, *Perca fluviatilis*, morphologic expression of yellow perch is largely plastic. Moreover, even if yellow perch morphologic expression is largely plastically-controlled, it is unclear how different environmental conditions influence morphologic expression during ontogeny. To address these uncertainties, we have conducted a series of experiments on yellow perch. We demonstrate how two habitats, pelagic and littoral, produce divergent morphologies in perch and then further explore components of these environments (i.e. diet, structure, predation risk) as drivers for altering morphology. The results show how perch environment drives morphological change, and therefore brings us closer to understanding plasticity and the role of phenotypic diversity in Great Lakes fish. *Keywords: Phenotypic Diversity, Fish behavior, Morphological Plasticity, Yellow perch, Fish populations.*

MANDELIA, A.[1], CHILD, M.[1], BEJANKIWAR, R.S.[1], DEMPSEY, D.A.[2], and WARWICK, C.[3], [1]International Joint Commission, 100 Ouellette Avenue, Windsor, ON, N9A 6T3, CANADA; [2]International Joint Commission, 2000 L Street NW, Washington, DC, 20440, USA; [3]International Joint Commission, 234 Laurier Street, Ottawa, ON, K1P 6K6, CANADA. **Life After Delisting for Former Great Lakes Areas of Concern.**

In the last 22 years, 7 Great Lakes Areas of Concern have been delisted - with 4 having been delisted since 2010, and another 10 scheduled over the next 5 years (Great Lakes Commission, 2015). The delisting process brings together communities, multiple levels of government agencies and other stakeholders to clean up contamination causing identified beneficial use impairments. However, there are no AOC-specific programs to help communities with newly delisted AOCs navigate the beginning of post-delisting life. The purpose of this study was to provide advice to communities with listed AOCs on how they can, through existing governance mechanisms, monitor and maintain remediated conditions after delisting; and how local community governance mechanisms can fill the gaps in federal and state agency programs. Individuals involved with delisted AOCs were interviewed to determine what common and unique strategies were employed among delisted AOCs to maintain the remediated sites. A preliminary summary of the strategies and their effectiveness will be presented; which will then inform possible International Joint Commission recommendations regarding future Stage 3 Remedial Action Plans / Final Delisting Reports. *Keywords: Public participation, Areas of Concern, Water quality, Local governance.*

MARINO, J.A.[1], PEACOR, S.D.[1], BUNNELL, D.B.[2], VANDERPLOEG, H.A.[3], POTHOVEN, S.A.[4], BALDRIDGE, A.K.[3], and IONIDES, E.L.[5], [1]Michigan State University, Department of Fisheries and Wildlife, East Lansing, MI, USA; [2]U.S. Geological Survey, Great Lakes Science Center, Ann Arbor, MI, USA; [3]National Oceanic and Atmospheric Administration Great Lakes Environmental Research Laboratory, Ann Arbor, MI, USA; [4]NOAA, Great Lakes Environmental Research Laboratory, Lake Michigan Field Station, Muskegon, MI, USA; [5]University of Michigan, Department of Statistics, Ann Arbor, MI, USA. **Assessing drivers of Lake Michigan zooplankton dynamics using state-space models.**

Species introductions are believed to have caused dramatic shifts in Great Lakes zooplankton species composition and production, which may have contributed to recent declines in some fisheries. Greater understanding is needed for the effects of major invaders, such as the spiny water flea (*Bythotrephes longimanus*). To assess Bythotrephes effects on zooplankton, we developed models of *Bythotrephes*-mesozooplankton interactions in a state-space model framework. We fit the models to offshore seasonal time series from Lake Michigan (1994-2012) using a recently developed, maximum likelihood-based optimization method (iterated filtering). The results indicate that Bythotrephes strongly influences the dynamics of dominant zooplankton species (e.g., *Daphnia mendotae*) and provide estimates for key biological parameters, such as predation rates. Furthermore, our approach has offered insights into the influence of other drivers, such as seasonal forcing and algal food availability, as well as the contribution of measurement error to observed variation over time. Our study therefore demonstrates a novel approach that can be used to enhance inference and prediction for Great Lakes species interactions and dynamics. Our findings also have implications for mitigating invasive species impacts and consequences to fisheries.
Keywords: Mathematical models, Bythotrephes cederstroemii, Zooplankton.

MARKLE, C.E. and CHOW-FRASER, P., McMaster University, 1280 Main Street West, Hamilton, ON, L8S 4K1, CANADA. **Can thermal characteristics be used to identify Blanding's turtle overwintering sites?**

Habitat creation is a necessary strategy to protect populations of Blanding's turtles (BT) living in settled areas of southern Ontario. Very little is known about overwintering requirements for this species, except that they must find water bodies that do not freeze and yet are sufficiently cold to allow them to stay dormant for the duration of the winter. We used water temperature data associated with BT populations at the southern and northern extent of their Ontario range to define thermal characteristics of occupied and unoccupied overwintering sites. From fall through spring in 2012 to 2014, we collected water temperature data and radio tracked BT to identify overwintering sites. During the pre-overwintering and overwintering seasons, we found BT occupying sites that were significantly cooler compared to unoccupied sites. At both northern and southern sites, BT used water bodies with an average overwintering water temperature of 1.97°C; all sites met the minimum critical temperature and maximum supercooling duration criteria. Using these parameters, we correctly identified suitable overwintering sites for a central BT population. These thermal characteristics of suitable overwintering habitat for BT should be applicable throughout the Great Lakes basin in Ontario. *Keywords: Reptiles, Habitats, Wetlands.*

MARKOVIC, S.[1], CADENA, S.[1], WATSON, S.B.[2], ARCHONDITSIS, G.[1], and DITTRICH, M.[1], [1]University of Toronto Scarborough, 1265 Military Trail, Toronto, ON, ON, M1C 1A4, CANADA; [2]Environment Canada, National Water Research Institute, 867 Lakeshore Rd, Burlington, ON, L7R 4A6, CANADA. **Phosphorus cycling in Hamilton Harbour sediments.**

Despite significant reduction of external phosphorus (P) loading since the 1970s, eutrophication and extensive algal blooms are persistent problems in the Hamilton Harbour. Modelling studies suggest considerable input of phosphorus from sediments. However, this flux is not well constrained and factors controlling P release are not well understood. Our study aims to fill this gap. We investigated two sites, located in the central (deep) basin (HH 1001) and shallow south-western part of the harbour (HH 9031). Using microsensors, we measured redox, O_2, and pH profiles across sediment-water interface; in pore water, concentrations of phosphorus and metals (Fe, Mn) were analyzed; P binding forms were determined using sequential extraction. The total P content in surface sediments (<5cm) is high (2-2.5 mg/g dry weight) and the dominant binding forms are redox-sensitive, organic matter and Al hydroxide bound P. The FeOOH : $Al(OH)_3$ ratio in sediments is low, which suggests that P retention capacity is limited. Notwithstanding high P content and seasonal anoxia, calculated diffusive P fluxes from sediments are moderate, with the highest values

measured during late summer (0.9 and 0.5 mg m^2 d-1 for HH 1001 and HH 9031 respectively). *Keywords: Hamilton Harbour, Phosphorus, Eutrophication.*

MARSHALL, N.T., KLYMUS, K.E., and STEPIEN, C.A., University of Toledo Lake Erie Center, 6200 Bayshore Rd., Toledo, OH, 43616, USA. **A High-Throughput Sequencing Assay to Detect and Identity Composition of Dreissenid Communities.**

The Great Lakes are one of the most invaded aquatic habitats, numbering 186 invasive species, including the notorious dreissenid mussels (zebra and quagga). Detecting invasive species prior to establishment and at all life stages greatly increases chances of eradication and control. Environmental (e)DNA (i.e., genetic material shed from living organisms via urine, mucus, tissues, filter feeding, etc.) is a powerful technique to assess the presence/absence of invasive and/or rare species, which is especially effective at low population levels compared to traditional sampling. However, most eDNA assays just reveal single species presence/absence, lacking information about relative abundances and genetic diversity. We are developing and testing a rapid high-resolution diagnostic assay to identify and evaluate the relative proportions of dreissenid taxa within North American invasive communities. This assay utilizes eDNA or biological samples (e.g., planktonic larval tows) and results are being used to address foundational ecological and population genetic questions, as well as help inform management agencies about the populations of invasive taxa. The accuracy of the assay was evaluated with simulated communities of known DNA concentrations, to reveal the composition, diversity, and relative abundances of component taxa. *Keywords: Zebra mussels, Dreissena, Invasive species, Quagga mussels, Genetics, Mollusks.*

MARTZ, M.A. and MCCARTNEY, A., Pennsylvania Sea Grant, 301 Peninsula Drive, Suite 3, Erie, Pe, 16505, USA. **Leveraging Research, Education and Outreach Staff to Develop a Basin-wide Marine Debris Campaign.**

Though the issue of marine debris is well known on marine coasts, recently researchers have discovered that the Lower Great Lakes contain higher quantities of plastic particles than the world's oceans. The National Sea Grant College Program funded a marine debris training for Great Lakes Sea Grant staff scheduled for April, 2016. It will provide an overview of current research on the presence and distribution of marine debris, especially plastic, in the Great Lakes, along with potential impacts on water quality and wildlife health. The Sea Grant professionals who attend this training will work with staff from NOAA's Marine Debris program to review current approaches and determine outreach gaps as they develop strategies designed to educate and engage municipal officials; clean marinas; anglers; educators and students; and other stakeholders. Although the initial training was targeted to

Sea Grant staff, we invite researchers, educators and outreach staff from around the basin to join us to learn more about this effort and how you can get involved. *Keywords: Microplastics, Marine debris, Environmental education, Outreach strategies, Toxic substances.*

MCCARTHY, F.M.G.[1], KORNECKI, K.M.[2], GARNER, C.S.[1], and KATZ, M.E.[2], [1]Brock University, 1812 Sir Isaac Brock Way, St. Catharines, ON, L2S 3A1, CANADA; [2]Rensselaer Polytechnic Institute, 110 8th Street, Troy, NY, 12180, USA. **Non-pollen palynomorphs as biomonitors of anthropogenic impact on Lake George, NY.**

Lake George, NY is a headwater lake with Class AA Special water quality rating that is part of the St Lawrence watershed. Surrounded by forever wild forest, it is an important tourism resource, but increasing anthropogenic impact has been noted, particularly in the southern part of the lake. The acid-resistant remains of microfossils in Ekman grab samples record different intensities and types of anthropogenic influence on different parts of the lake (e.g., salt-loading, eutrophication, pollution, temperature) that we can compare with water-quality data from RPI's Darrin Fresh Water Institute. Non-pollen palynomorphs (NPP) include a wide variety of acid-resistant remains of algae, protozoans, fungi, and animals with a variety of life habits and ecological preferences that are commonly found in pollen slides. The spatial distribution of NPP is compared with the distribution of testate amoebae whose sensitivity to various types of impact has been well documented, and these insights are applied to paleolimnological reconstruction of water quality. Changes in the abundance and diversity of NPP (particularly dinoflagellate cysts and the remains of green algae) associated with the *Ambrosia* (ragweed pollen) rise in cores from Paradise Bay, Northwest Bay and Dome Island Channel are attributed to Euro-American settlement. *Keywords: Algae, Microfossils, Paleolimnology.*

MCCARTHY, M.J.[1], HAMILTON, S.K.[2], MYERS, J.A.[1], and NEWELL, S.E.[1], [1]Wright State University, 3640 Colonel Glenn Hwy, Dayton, OH, 45435, USA; [2]Michigan State University, Kellogg Biological Station, 3700 East Gull Lake Drive, Hickory Corners, MI, 49060, USA. **Effects of Nitrogen on Phosphorus Flux from Wetland Sediments: Implications for Nutrient Management.**

Groundwater nitrogen pollution has been linked to increased internal phosphorus (P) loading in wetland sediments via interferences with iron and sulfur biogeochemistry. We tested this hypothesis in the Kellogg Forest pond (Michigan) in September 2014. The shallow pond (depth < 1 m) functions as a created wetland and receives diverted water from Augusta Creek, which flows through the experimental forest. Ambient NOx concentrations entering and exiting the pond were approximately 63.5 and 59.5 μM, respectively. Intact pond sediments were incubated in a continuous-flow system at both ambient and room

temperatures (inflow reservoirs) and ambient and enriched nitrogen (as ammonium or nitrate) concentrations. Unamended sediments acted as a P sink (mean uptake ≈ 0.5 μmol P m^{-2} h^{-1}) at both inflow temperatures, but sediments enriched with ammonium or nitrate reversed to a P source (mean ≈ 1.0 μmol P m^{-2} h^{-1}) at ambient inflow reservoir temperature. Sediments with room temperature inflowing water ceased being a P sink but did not release significant amounts of P. While the vast majority of eutrophication management focus has been on reducing P loads, these results suggest that nitrogen management in the watersheds of eutrophic lakes may also be necessary to reduce internal P loading.
Keywords: Eutrophication, Nitrogen, Phosphorus, Internal loading.

MCCLYMONT, A., TEBRUGGE, V., and KANAVILLIL, N., Lakehead University, Orillia, ON, CANADA. **Zooplankton community dynamics along the Trent Severn Waterway.**

Water quality monitoring is essential in understanding human related impacts on aquatic ecosystems. The Trent Severn waterway (TSW) is a 360 km waterway which connects Lake Ontario and Georgian Bay. There is limited information published on zooplankton and phytoplankton population patterns and trends in this waterway. Historically this waterway has been used by fur traders while in modern times this waterway serves as an important economic resource. Additionally, it provides habitats for different wildlife and fish species. This study monitored the zooplankton and phytoplankton populations at eleven sampling locations in Lake Simcoe and Lake Couchiching, two connecting water bodies of TSW, during fall of 2015. Other water quality parameters monitored included dissolved oxygen, temperature, total nitrate, total phosphorous, conductivity and pH. The data analysis will provide information on species composition and dynamics of zoo and phytoplankton in these water bodies with respect to the location of sample collection and a possible relationship between their distribution and water quality parameters. The possible benefits of this study include potential use of zooplankton and phytoplankton as indicators of water quality that will help in the restoration efforts of the cold water fishery in this area. *Keywords: Zooplankton, Lake Couchiching, Water quality, Lake Simcoe.*

MCCONNELL, C.J.[1], JAMES, A.L.[2], and YAO, H.[1], [1]Dorset Environmental Science Centre, 1026 Bellwood Acres Road, Dorset, ON, P0A 1E0, CANADA; [2]Dept. of Geography, Nipissing University, 100 College Drive, North Bay, ON, P1B 8L7, CANADA. **The Simplified Isotope Mass Balance Approach in Seasonally Stratified Lakes, South-Central Ontario.**

Long term monitoring of headwater lakes by the Dorset Environmental Science Centre (DESC) in south-central Ontario has documented trends in lake water chemistry and impacts to resident biota. Trends include decreases in calcium and phosphorous and increases in dissolved organic carbon yet spatial surveys have been unable to explain inter-lake variability. A simplified Isotope Mass Balance (IMB) is a survey based approach capable of exploring relationships between lake water balance components and lake chemistry. The method does not lend itself to lakes which are not well mixed however and the underlying assumptions need to be evaluated for this region. In 2013, sampling of stable water isotopes was added to longterm monitoring of DESC study lakes to test the IMB approach in improving our understanding of the linkages between lake water balance and lake chemistry. Bi-weekly sampling of lake stable isotope profiles for the ice-free season (2013), and weekly to bi-weekly isotope/chemistry sampling of stream inputs and lake exports through the 2010 - 2013 field seasons were completed. Using a basic conceptual framework for the isotopic evolution of stratified lakes the assumptions of the IMB are evaluated to better understand its use within a range of seasonally stratified lakes. *Keywords: Stable isotopes, Hydrologic budget, Mass balance.*

MCDANIEL, T., RYAN, A., DEJONG, M., MACDONALD, J., GUE, A., HILL, R.B., KLAWUNN, P., LALONDE, B., RONDEAU, M., TOBIN, O., WALTHO, J., and MCNAUGHTON, B., Environment and Climate Change Canada, Various, CANADA. **Power Analysis for Trend Detection of Water Quality Parameters for a National Monitoring Network.**

A key objective of Environment and Climate Change Canada's Fresh Water Quality Monitoring program is the ability to detect changes in trends in long term water quality data, in particular in response to anthropogenic stressors and remedial management actions. A power analysis was conducted to assess the ability to accurately detect monotonic temporal trends in key water quality parameters. Power was estimated using a Monte Carlo simulation for a non-parametric seasonal Kendall test. We estimated site and parameter specific power evaluations of the current sampling program against alternative sampling designs (i.e. reduced sampling frequencies) and compared this across ECCC's national network of water quality monitoring sites. In general, reducing sampling frequency led to a reduction in the power to detect trends. We consistently had greater than 80% power to detect small trends (20% increase in concentration over a 10 year time period) in many dissolved parameters (Ca, Na, K, Mg, Cl, SO_4, DO, Ba, specific conductance) even when sampling frequency was dropped to quarterly. The power to detect trends in some parameters, such as total phosphorus, was inconsistent, with the magnitude of the minimum detectable trend varying widely between sites. Factors that affect the ability to detect trends in these variables are explored. *Keywords: Water quality, Statistical power, Assessments, Monitoring.*

MCGOLDRICK, D.J., CLARK, M.G., KEIR, M.J., and MALECKI, M., Environment Canada, Burlington, ON, L7S 1A1, CANADA. **Trends of polybrominated diphenyl ethers in Canadian fish.**

Environment Canada has conducted monitoring of polybrominated diphenyl ethers (PBDEs) in fish from locations across Canada as part of commitments under the Great Lakes Water Quality Agreement and to support risk management activities under Canada's Chemicals Management Plan. Across Canada, PBDEs are found at the highest concentrations in the Great Lakes and St. Lawrence River. Federal Environmental Quality Guidelines (FEQGs) have been established for the most abundant BDE homologues present in fish (tetra-, penta-, and hexa-BDEs). While concentrations of penta-BDE often exceed FEQGs, those of penta- and hexa-BDE are below the guidelines. At most locations, the levels of PBDEs in fish have plateaued and/or have declined since the voluntary phase-out of production and regulations began in the mid to late 2000s. In the Canadian waters of the Great Lakes, levels are declining most slowly in Lake Superior, such that current concentration in Lake Superior are on par with those observed in Lake Ontario and Lake Huron on a wet weight basis. On a lipid-weight basis, levels of PBDEs in Lake Trout from Lake Superior are higher than in the other Great Lakes. Congener specific trend analysis in Lake Trout from Lake Ontario may also provide some insight into possible debromination pathways of the fully brominated congener BDE209. *Keywords: Contaminant trends, Fish, Flame retardants.*

MCKNIGHT, E.[1], HIK, D.[1], and CARMACK, E.[2], [1]Department of Biological Sciences, University of Alberta, Edmonton, AB, CANADA; [2]Fisheries and Oceans Canada, Victoria, BC, CANADA. **Baseline Characterization of Spatial and Temporal Dynamics for Kluane Lake, Yukon.**

Kluane Lake is the largest lake entirely within Yukon, Canada (~400km^2 surface area; 90m a its deepest point; ~5400km^2 watershed approximately 1100 of which is glaciated).Its watershed extends from the central St. Elias Icefields to the Ruby Range and drains into the greater Yukon River watershed. Because of its size and latitude, its importance to tourism and fishing, its complex limnology, and its significance to First Nations, Kluane Lake is a model study lake to better understand how climate change may affect northern lakes and watersheds.A lack of hydrological historical data for Kluane prompted the first comprehensive baseline study in 2015.Physical, chemical, and biological water property data was collected throughout the lake and water column during all four seasons. Sondes were deployed to collect data on water temperature, turbidity, conductivity, oxygen, and pH. Water samples were collected and processed for major nutrients (nitrogen and phosphorous) as well as chlorophyll a. This data will be used to characterize basic lake dynamics for Kluane. Additionally, this comprehensive baseline will be used to design a long term monitoring program for Kluane so that any changing trends in water properties due to climate change may be identified and appropriate policy and management actions may be taken. *Keywords: Arctic, Spatial analysis, First Nations.*

MCLAUGHLIN, R.L.[1] and REID, K.B.[2], [1]University of Guelph, 50 Stone Road E, Guelph, ON, N1G 2W1, CANADA; [2]Ontario Commercial Fisheries' Association, 45 Jame St., Blenheim, ON, N0P 1A0, CANADA. **Contribution of Next-generation Fisheries Research Networks to Resolving Wicked Fisheries Problems.**

Research to improve understanding of risks to the sustainability of commercial and sport fisheries, and the challenges for stakeholder-engaged governance of multi-jurisdictional, transboundary fisheries, has been central to the Canadian Fisheries Research Network (CFRN) and to the Decision Analysis and Adaptive Management Project specifically. The 'Great Lakes node' of the CFRN was funded by an NSERC Strategic Research Networks between 2010 and 2015. Experience over this period indicated that collaboration is key to improved industry-academic-government coordination for sustaining freshwater fisheries. In particular, an even broader stakeholder community is very likely to benefit significantly from involvement in future research networks with additional non-government organizations and government agencies. The purpose of this presentation is to raise awareness among governments, non-government organizations, stakeholders and academics about emerging plans for a second national research network and to stimulate interest in the development of collaborative projects in the Great Lakes basin.
Keywords: Decision making, Fisheries governance, Fish management, Policy making, Public participation, Risk.

MCLEOD, A.M.[1], PATERSON, G.[2], and HAFFNER, G.D.[1], [1]Great Lakes Institute for Environmental Research, 401 Sunset Ave., Windsor, ON, N9B3P4, CANADA; [2]Department of Environmental and Forest Biology, Syracuse, NY, USA. **The Lake Huron Story: Putting The Pieces Together Using Contaminant Tracers.**

Lake Huron is experiencing substantial change including declines in primary production, regime shifts in the pelagic fish community, invasive species, and climate change. These stressors have caused decreased growth rates of Lake Trout populations,

increased the dominance of older individuals, and caused declines in the Pacific Salmon abundances. Previously, we proposed the use of polychlorinated biphenyls (PCBs) as a metric to measure nutrient and energy flow in aquatic systems, here we extend that concept to the entire food web of Lake Huron, demonstrating their use in quantifying basin differences in ecological efficiencies. By using individual consumption and condition estimates, as well as individual foraging times, we are able to examine the health of the three distinct basins. The Georgian Bay supports both predator and prey fish with high condition, the highest consumption rates, and the greatest asymptotic length. However, the high consumption rate is likely a result of lower densities of fish in the Georgian Bay (State of Lake Huron, 2010), as top predators also spend the more time searching for their meals. This suggests that the declines in Lake Trout densities and condition in recent years are related declines in prey abundance and increased search efforts required to meet nutritional requirements. *Keywords: Food chains, Lake Huron, Ecosystem health.*

MCPHILLIPS, L.E., MORSE, N.R., and WALTER, M.T., Cornell University, Ithaca, NY, 14853, USA. **Maximizing Ecosystem Services in Stormwater Detention basins: A Focus on Nutrient Cycling.**

Stormwater detention basins are a common feature in developed landscapes. As there is increasing pressure on open space in urban areas, it is important to understand how we can maximize ecosystem services provided by these green infrastructure features. They are primarily designed to manage storm runoff and trap suspended sediments and associated pollutants. Retaining nutrients are often not a design focus. Our research focuses on maximizing beneficial nutrient retention processes like denitrification, which transforms nitrate into gaseous nitrogen. In stormwater detention basins on the Cornell University campus in Ithaca, New York we found significantly higher rates of potential denitrification in basins which remained wet compared to basins which drained much more quickly. We also found that these same wet conditions which promoted denitrification also promoted emission of the greenhouse gas methane, which would be considered an 'ecosystem dis-service'. Analysis of microbial DNA in basin soils mirrored these process observations, finding greater abundance of genes for the denitrification pathway in the wet basins. In the future, we can use this information to improve management of stormwater, designing basins which maximize ecosystem services like denitrification and minimize disservices like greenhouse gas emissions. *Keywords: Urban watersheds, Greenhouse gases, Nutrients, Water quality.*

MEDELLIN-AZUARA, J.[1], GOODWIN, P.[2], ENRIGHT, C.[3], LUND, J.R.[1], and BRAY, B.[4], [1]University of California, Davis, One Shields Ave., Davis, CA, 95616, USA; [2]University of Idaho, 322 Front St., Boise, ID, 83702, USA; [3]Delta Stewardship Council, 980 9th St., Sacramento, CA, 95814, USA; [4]East Bay Municipal Utility District, 375 11th St., Oakland, CA, 94607, USA. **Integrated Environmental Modeling of Estuarine Systems.**

Models are essential in organizing scientific thinking and communicating the results in an unbiased and comprehensible way - with assumptions clearly stated and uncertainty quantified. Models encapsulate our current knowledge, accelerate knowledge discovery, aid making projections about alternative futures based on expected conditions, and should be continuously updated. We explored ways on how models could be advanced at a more rapid pace, informing revisions of monitoring programs, accelerating knowledge discovery, and communicating model results to agencies and those responsible for making management decisions of large estuarine systems. The concept of a collaboratory is proposed that comprises physical space, a virtual network and a structure that can draw together modeling experts from across disciplines, organizations and geographic areas to tackle identified problems. Examples could be refined algorithms, constructive comparisons of different modeling approaches or articulations of alternative futures. *Keywords: Deltas, Ecosystem modeling, Estuaries.*

MEDELLIN-AZUARA, J.[1], HOWITT, R.E.[1], MACEWAN, D.M.[2], and LUND, J.R.[1], [1]University of California, Davis, One Shields Ave., Davis, CA, 95616, USA; [2]ERA Economics, Kennedy Pl, Davis, CA, 95616, USA. **Managing for Droughts: Recent Impact Studies for California.**

Droughts provide great opportunities to learn about vulnerability and resilience of water systems to scarcity. In California, an arid place with highly-engineered systems has demonstrated remarkable resilience to droughts as systems recover promptly and urban and agricultural demands are mostly fulfilled. However, environmental systems remain vulnerable and prone to reduction. We explore economic and environmental impacts of recent California drought and adaptation. We quantify economic impacts using a suite of models for water availability, agricultural production, and groundwater. We provide some policy insights to better manage future droughts and improve understanding of adaptation.
Keywords: Management, Economic impact, Drought.

MEHDIZADEH ALLAF, M., DULAL-WHITEWAY, C.J., and TRICK, C.G., Department of Biology, Western University, 1151 Richmond Street, London, ON, N6A 5B7, CANADA. **Yeast cell as a bio-model for measuring the toxicity of harmful algal blooms (HABs).**

Harmful algal blooms are significant environmental problems. Cells that bloom are often associated with intercellular or dissolved toxins that are a grave concern to human

health. But cells may also excrete compounds that are beneficial to their competition allowing the cells to establish or maintain cells in bloom conditions. Here, we develop a yeast cell assay to assess if bloom forming species change the toxicity of the water environment. Current methods to assess toxicity involve whole-organism assessment. Here, yeast cells are used as a bioassay model to evaluate eukaryotic cell toxicity. Yeast is a commonly used, easy to maintain bioassay species, free from ethical concerns but sensitive to a wide array of metabolic and membrane-modulating agents. Compared to using the whole-organism, this method offers rapid and convenient cytotoxicity measurements using a lower volume of samples. The flow cytometer was employed in this toxicology assessment to measure the number of dead cells using alive/dead stain analysis. The results show that yeast cells were metabolically damaged after 1 hour of exposure to our model toxin-producing euryhaline flagellates (*Heterosigma akashiwo* and *Prymnesium parvum*) cells or extracts. The mortality rate of yeast cells was 50% after 1 hour of exposure and increased to 70% after 3 hours
Keywords: Harmful algal blooms, Toxic substances, Yeast cells, Algae.

MEHLER, K.[1], BURLAKOVA, L.E.[1], KARATAYEV, A.Y.[1], and CEVAER, A.G.[1], [1]Great Lakes Center, SUNY Buffalo State, 1300 Elmwood Ave, Buffalo, NY, 14222, USA; [2]Research Foundation of SUNY Buffalo State, Office of Sponsored Programs, 1300 Elmwood Ave, Buffalo, NY, 14222, USA. **Benthic invertebrate assessment in the lower Niagara River: Distribution and community structure.**

Although identified as "impaired" the structure and functioning of the Niagara River benthic community are currently poorly understood. In 2014 140 benthic samples were taken along a 10 km stretch of the lower Niagara River to assess diversity, abundance and spatial distribution of benthic invertebrate community. Abiotic data such as bottom substrate, water depth, and flow velocities were used to generate benthic habitat maps that link the physical habitat with biotic information. So far, 105 benthic species were identified and their spatial distribution is currently being analyzed using non-parametric multivariate methods in Primer 7. Invertebrate abundance and species richness were highest in shallow areas (depth < 5m) with soft substrate ranging from silty sand to gravel and presence of macrophytes. Results from this study will help to assess the current status of benthic community in different habitats and select valuable habitats for conservation and as potential feeding grounds for the endangered lake sturgeon (*Acipenser fulvescens*).The benthic maps also serve as a basis to evaluate habitat quality and develop effective management strategies for the Niagara River. *Keywords: Spatial distribution, Benthos, Niagara River.*

MELZER, R. and O'NEILL, C., Ontario Ministry of the Environment and Climate Change, 135 St Clair Ave W, 6th fl, Toronto, ON, M4V1P5, CANADA. **Lake Simcoe: Great Lakes "lessons learned" and Ontario's new Great Lakes Protection Act.**

On November 3, 2015, the Great Lakes Protection Act, 2015 received Royal Assent. This act was developed through years of extensive partner and public engagement and consultation. It is designed to help align actions across Ontario ministries (environmental, economic and social), with local partners, stakeholders, the public, and other governments and jurisdictions. The Act recognizes that responding to Great Lakes issues requires a variety of programs and decisions to work together (e.g., stewardship, land use decisions, approvals, etc.). The Act supports science, monitoring, and transparent reporting to inform collaborative action. Key elements of the Great Lakes Protection Act, including provisions related to Ontario's Great Lakes Strategy and to geographically-focused initiatives, reflect policy learning from the Lake Simcoe experience. The Great Lakes legislation includes tools for geographic focusing of efforts, and a commitment to target-setting to address Great Lakes algal blooms. *Keywords: Policy making, Great Lakes Protection Act, Lake Simcoe.*

MENZA, C., KENDALL, M., CHRISTENSEN, J., and MONACO, M., NOAA/NOS/NCCOS, 1305 East-West Highway, SSMC4/9259, Silver Spring, MD, 20910, USA. **Biogeographic Assessments: A Tool for Information Synthesis in Spatial Planning.**

Spatial planning is rapidly emerging as a viable approach for comprehensive and efficient management of coastal and marine environments around the world. Implementing spatial planning, however, is a considerable challenge for stewardship agencies; in large part because gaps exist in available data and syntheses of data on spatially heterogeneous and dynamic socio-ecological systems are extremely complex. This talk will provide an overview of the Biogeographic Assessment Framework, a collaborative analytical framework for data synthesis and analysis used to create geospatial tools for coastal managers. The framework incorporates concepts and techniques from traditional ecology, sociology and economics, remote sensing, spatial ecoinformatics and computer science. We will show how the framework was used to integrate data from multiple monitoring programs, generate collaborative and operational synthesis maps, and share digital data. *Keywords: Biogeographic assessment, Spatial planning, Information synthesis.*

METCALFE, B.[1], LANTRY, B.[2], and HOYLE, J.[1], [1]Ontario Ministry of Natural Resources and Forestry, Glenora Fisheries Station, Picton, ON, CANADA; [2]U.S. Geological Survey, Lake Ontario Biological Station, Oswego, NY, USA. **Has the Feeding Behaviour of Lake Trout Changed In Response To Shifts in the Prey Fish Community?**

Lake trout (*Salvelinus namaycush*) in Lake Ontario have witnessed many changes over the past century. Understanding the diets of lake trout in an ever-changing ecosystem can help us better understand their ecology, productive capacity, and the potential for restoration of a self-sustaining lake trout population. To characterize lake trout feeding ecology in both Canadian and American waters of Lake Ontario we will examine stomach contents from lake trout collected over a 55+ year time period. With emphasis towards ongoing prey fish community changes, diet results will be examined spatially and temporally, and will be related to changes in prey fish abundance, distribution, and community composition. *Keywords: Lake trout, Diets, Lake Ontario.*

MEYER, K.A.[1], SMITH, D.J.[1], FENNO, J.[1], WATSON, S.B.[2], DAVIS, T.W.[3], and DICK, G.[1], [1]University of Michigan, Department of Earth and Environmental Sciences, 1100 North University Ave., Ann Arbor, MI, 48109, USA; [2]Canadian Centre for Inland Waters, Environment Canada, Burlington, ON, L7R 4A6, CANADA; [3]NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Rd., Ann Arbor, MI, 48108, USA. **Incorporating Great Lakes Isolates of *Microcystis* sp. to Comparative Genomics Studies.**

The bloom-forming cyanobacterium *Microcystis* has been studied on a genomic level in ecosystems worldwide but few data exist from strains isolated from the Laurentian Great Lakes. *Microcystis* blooms occur annually in western Lake Erie and other regions such as Saginaw Bay, Lake Huron, and Green Bay, Lake Michigan, posing a threat to drinking water supplies, recreation, and ecosystem dynamics. In this study we compared the genomes of twenty *Microcystis* sp., three of which were isolated from the Great Lakes. These data provide an up to date estimate of the core and pan-genome of *Microcystis* and identifies several genes unique to strains from the Great Lakes. The core genome of *Microcystis* is ~1900 genes, which is slightly lower than previous estimates obtained with fewer genomes and represents ~11% of identified genes. However, the pan-genome remains open, with over 60% of identified genes found in only 1 or 2 strains of *Microcystis* compared in this study. Each Great Lakes strain of *Microcystis* contained around 960 genes not found in other Great Lakes isolates, of which about 300 were completely unique genes (not found in another other currently sequenced strains of *Microcystis*). *Keywords: Harmful algal blooms, Genomics, Microcystis.*

MICHAUD, G.J.E., BUTTS, E.K., VANCE, J., and CARRICK, H.J., Central Michigan University, Mt. Pleasant, USA. **Spatio-temporal Variation of Phytoplankton Nutrient Status in the Upper Great Lakes Region.**

The Laurentian Great Lakes have experienced substantial nutrient enrichment related to human settlement and industrialization, whereby excessive nutrient loading in the

1950-60s was evident. While water-quality acts in the 1970s have been successful in lowering nutrient loading pressures, the establishment of invasive species and alterations in region climate continue to influence the productivity of the Laurentian Great Lakes ecosystem. Nutrient enrichment bioassays (NEBs) were used to evaluate the current importance that key nutrients (N and P) have on phytoplankton growth. As such, we employed a series of bioassay experiments from 2012 to 2015 to evaluate the growth response of natural phytoplankton assemblages to experimental N and P enrichment in a 2 x 2 factorial design. NEBs were conducted seasonally and spatially on assemblages in Lakes Michigan and Superior (n=60). Our results also showed that P has become more acutely limiting in Lake Michigan, possibly because phytoplankton biomass has declined in the lake. Co-limitation of N and P was rarely observed; this condition occurred in locations where phytoplankton biomass was relatively large (e.g., Muskegon Lake, nearshore Lake Michigan). Last, internal poly-phosphate storage within native phytoplankton was a reliable indicator for the degree of P limitation. *Keywords: Great Lakes basin, Nutrients, Phytoplankton.*

MIDWOOD, J.D.[1], DARWIN, A.[2], GRABAS, G.[3], and DOKA, S.E.[1], [1]Fisheries and Oceans Canada, Burlington, CANADA; [2]Canadian Wildlife Service - Environment Canada, Ottawa, CANADA; [3]Canadian Wildlife Service - Environment Canada, Toronto, CANADA. **Non-Native Starry Stonewort in Lake Ontario.**

Starry stonewort (*Nitellopsis obtusa*; herein Nitellopsis) was introduced to the Laurentian Great Lakes in the late 1970s. Since its introduction, little research has been conducted within the Great Lakes basin to determine the distribution and explore the ecology of this non-naitve macroalgae. Indeed, in many field surveys this species has been misidentified and grouped with other native Characeae (e.g., *Nitella* spp.). Here we discuss the environmental factors that influence the distribution of Nitellopsis at two spatial scales. First, a detailed survey of Nitellopsis within a single embayment (Presqu'ile Bay, Lake Ontario) found that fetch, conductivity, and boating activity influenced its distribution. Next, a large-scale survey of wetlands along the Canadian shoreline of Lake Ontario found Nitellopsis in high densities only in eastern Lake Ontario. Finally, given its wide spatial distribution and high density of growth in some areas, the potential negative effects of this non-native macroalge on nearshore aquatic habitat and associated fish communities in the lower Great Lakes are discussed. Given the paucity of knowledge regarding both the full distribution of Nitellopsis in the Great Lakes and how its introduction has influenced native flora and fauna, it is hoped this study will spur future work. *Keywords: Nitellopsis, Wetlands, Macroalage, Biological invasions, Lake Ontario.*

MILLER, R.J.[1], JOHENGEN, T.H.[1], VANDERPLOEG, H.A.[2], HOFFMAN, J.[3], HOLLENHORST, T.[3], FIORENTINA, L.A.[4], and AUSTIN, J.A.[5], [1]CILER, 440 Church St, Ann Arbor, MI, 48109, USA; [2]NOAA-GLERL, 4840 S. State Road, Ann Arbor, MI, 48108, USA; [3]USEPA Mid-Continent Ecology Lab, Duluth, MN, USA; [4]NDBC, Stennis Space Center, MS, USA; [5], Large Lakes Observatory, University of Minnesot, Duluth, MN, USA. **Application of Underwater Gliders to Map Nearshore-Offshore Gradients During 2015 Lake Michigan CSMI.**

As part of 2015 Lake Michigan CSMI program, the Cooperative Institute for Limnology and Ecosystem Research (CILER), the University of Minnesota-Duluth (UMD), and the USEPA Mid-Continent Ecology Lab jointly operated a series of glider missions to extend ship-based observations being conducted by NOAA, EPA and USGS looking at a series of nearshore-offshore transects throughout the lake. In southern Lake Michigan, CILER partnered with NOAA-GLERL to conduct approximately 85 mission days of glider observations covering approximately 4000 vertical profiles over a spatial distance of 1900 km. The glider was equipped with sensors to measure the three dimensional structure of temperature, CDOM, Chlorophyll a, and PAR. Similarly, UMD partnered with EPA and USGS to run XX glider mission days in the northern half of the lake, conducting over XX profiles over XX km. Results will be presented to show regional differences in coastal inputs and biological distributions throughout the lake. *Keywords: Lake Michigan, Glider, Distribution patterns, Observing systems.*

MILLIGAN, M.S.[1], COCCARELLI, T.[1], DOUCETT, E.[1], CRIMMINS, B.S.[2], XIA, X.[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. **Identification and quantitation of chloro-methoxy-phenol analogues in Great Lakes fish.**

As part of our ongoing work with the EPA-sponsored Great Lakes Fish Monitoring and Surveillance Program, we have been analyzing Great Lakes fish tissue samples for possible stable environmental degradation products that may have been derived from legacy pollutants such as PCBs, organochlorine pesticides, PBDEs, and perhaps others. Whole fish Lake Trout composites from all five Great Lakes were extracted, and cleaned-up using automated GPC and deactivated silica gel columns. For identification, final extracts were analyzed using comprehensive two-dimensional gas chromatography, coupled with time-of-flight mass spectrometry (GCxGC-TOF). Using this technique, we have identified many analogues of chlorinated and brominated methoxylated phenols and acetylated phenols. By far the dominant congeners in this group are 2-chloro-4-methoxyphenol and 2-bromo-4-methoxyphenol, with concentrations of the former approaching the 1000 ng/g range in some samples. We have also analyzed a limited set of Great Lakes sediment and water

column samples and have detected none of the above compounds. Our hypothesis is that these chlorinated and brominated compounds may be derived as metabolic products within the fish. *Keywords: Environmental contaminants, Fish, Organochlorine compounds.*

MILT, A.W.[1], DIEBEL, M.W.[2], DORAN, P.J.[3], FERRIS, M.C.[4], MOODY, A.T.[1], NEESON, T.M.[5], O'HANLEY, J.R.[6], and MCINTYRE, P.B.[1], [1]Center for Limnology - University of Wisconsin - Madison, Madison, WI, USA; [2]Wisconsin Department of Natural Resources, Madison, WI, USA; [3]The Nature Conservancy - Michigan, Lansing, MI, USA; [4]Wisconsin Institutes for Discovery - University of Wisconsin - Madison, Madison, WI, USA; [5]University of Oklahoma, Norman, OK, USA; [6]University of Kent, Kent, ENGLAND. **Optimizing Barrier Removals in the Great Lakes Basin.**

Fish migration into tributaries is critical for lake fish population/community structure, fisheries production, nutrient exchange, and other processes. Migratory populations worldwide have been heavily impacted by the presence of artificial barriers to fish passage such as dams and culverts. While keeping some barriers is justified, barrier removal must be a major part of efforts to restore lake fish populations. To explore this issue, we developed a mathematical optimization model to prioritize barrier removals in the Great Lakes basin to restore accessibility to tributaries for migratory fishes. The model has allowed us to address key questions about large-scale barrier removals, some of which will be discussed in this presentation. In particular, we will discuss the benefits of planning at different spatial and temporal scales, rules of thumb for planning at multiple scales, and tradeoffs between beneficiary and invasive fish species. We will conclude with future extensions of the model and discuss implications for decision support within the Great Lakes basin and elsewhere. *Keywords: Migrations, Decision making, Spatial analysis.*

MISTRY, R. and ACKERMAN, J.D., University of Guelph, Department of Integrative Biology, Guelph, ON, N1G 2W1, CANADA. **Algal flux affects the clearance rates of recently metamorphosed freshwater mussels.**

Despite their ecological relevance, which is in large part a consequence of their suspension feeding activities, the early life history of unionid mussels is not well understood. We examined the suspension feeding (i.e., clearance rates, *CR*) by recently metamorphosed juvenile *Lampsilis siliquoidea* (1 - 4 week old), *Lampsilis fasciola* (1 - 3 week old), *Villosa iris* (2 week old), and *Ligumia nasuta* (1 week old) under ecologically relevant flux conditions in a recirculating racetrack flow chamber system. The range of velocities examined was determined experimentally using a permeameter containing riverbed material (63 um to 6.5 cm diameter) in which juvenile mussels are thought to reside. The *CR* of the juvenile unionid species increased linearly with algal flux and the ranking of *CR* among species was *V. iris* >

L. siliquoidea > *L. nasuta* > *L. fasciola*. *CR* also increased with the age (size) of the mussel cohort but *CR* increased nonlinearly with shell length of the individual within a species. These results provide new insight into the feeding abilities of recently metamorphosed juvenile mussels as well as potential threats to their growth and survival, which will contribute to our understanding of their habitat requirements and assist in their conservation. *Keywords: Ecosystems, Benthos, Hydrodynamics.*

MITCHELL, K.T. and NEFF, B.D., Department of Biology, University of Western Ontario, London, ON, N6A5B7, CANADA. **The reproductive effects of thiamine deficiency in three populations of Atlantic salmon.**

Atlantic salmon (*Salmo salar*) were once abundant in Lake Ontario, but were extirpated by 1898. Efforts to reintroduce Atlantic salmon into Lake Ontario have not yet succeeded. One potential obstacle is the introduction of invasive forage fish, which can lead to a thiamine deficiency in salmonids. Previous studies on thiamine deficiency have documented negative effects, including lower swimming performance and body condition. To study the effects of thiamine deficiency, our salmon have been fed either a high-thiamine diet or a low-thiamine diet. Three populations of Atlantic salmon will be used to determine which strain has the best performance under a low-thiamine diet. Crosses will be done to investigate the effects of thiamine deficiency on reproduction, including juvenile performance and survival. Results will provide insight into which population may be better suited to the current environmental conditions of Lake Ontario, and how to manage the reintroduction efforts of Atlantic salmon. *Keywords: Salmon, Lake Ontario, Thiaminase.*

MOLNAR, S., Great Lakes Commission, Suite 100, 2805 South Industrial Highway, Ann Arbor MI, MI, 48104, USA. **Tools for Implementing Integrated Water Management.**

Over the past three years, in our Greater Lakes: Reconnecting the Water Cycle project, we have examined the environmental and financial impacts of our water supply, sewage, and stormwater management systems in six municipalities in the Great Lakes basin (3 Canadian & 3 U.S.) as examples from which we can learn lessons and approaches for municipalities throughout the Great Lakes basin. In this session we will present our findings and lessons learned. Our main findings focus on an integrated water management approach that: 1) makes decisions on water supply, use, and sewage and stormwater management as part of one system, rather than being separate systems; 2) focuses on both water use conservation/efficiency programs and green-infrastructure approaches to address human water needs in ways that are more linked to the natural water system; and 3) focuses at the watershed level instead of being unnaturally truncated by municipal boundaries. This

presentation will show some tools that we have developed to help move us forward to integrated water management. The author, John Jackson, is the project manager for this Great Lakes Commission project. It is funded by the Great Lakes Protection Fund.
Keywords: Urbanization, Hydrologic cycle, Conservation.

MOORE, L.P., COOPER, M.J., UZARSKI, D.G., and BOZIMOWSKI, A.A., Central Michigan University, 1200 S. Franklin St., Mt. Pleasant, MI, 48859, USA. **Nutrient limitation of algal biofilms 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. It is important to monitor the response of coastal wetlands to nutrient loading to better understand how human influences affect wetland function. This study used nutrient diffusing substrata (NDS) to determine the effect of wave energy on nitrogen (N) and phosphorous (P) limitations of periphyton biomass. Effects of wave energy on nutrient limitation were tested based upon location of NDS within each wetland. Treatments included N, P, N+P, and a control and were placed in inner, middle, and outer zones of each wetland. Biomass accrual at most locations appeared to be N-limited or N+P co-limited. The magnitude of N+P co-limitation increased from inner to outer zones in a majority of sites. The influence of N amendments on biomass decreased from inner to outer zones while the influence of P amendments increased from inner to outer zones. This suggests that wave action pushes nutrients, especially phosphorous, into inner zones where it is retained, while outer zones remain supplied with nitrogen from the adjacent lake. These results exhibit how wave exposure plays a critical role in nutrient dynamics and algal growth in coastal wetlands. *Keywords: Algae, Hydrologic gradient, Nutrients, Waves.*

MORATZ, C.C.[1], HOUGHTON, C.J.[1], FORSYTHE, P.S.[1], LAMBERTI, G.A.[2], UZARSKI, D.G.[3], and BERG, M.B.[4], [1]University of Wisconsin-Green Bay, 2420 Nicolet Dr, Green Bay, WI, 54311, USA; [2]University of Notre Dame, Notre Dame, IN, 46556, USA; [3]Central Michigan University, Mount Pleasant, MI, 48859, USA; [4]Loyola University Chicago, Chicago, IL, 60660, USA. **Growth and Ecology of Bowfin (*Amia calva*) in Green Bay, Lake Michigan.**

Lake Michigan has been heavily researched by ichthyologists, ecologists and fisheries managers, but many of the "rough species" have only been researched anecdotally. The growth and ecology of Bowfin (*Amia calva*) have not been adequately investigated in Lake Michigan. This study seeks to describe their longevity and growth, and investigate their feeding ecology. Bowfin were collected from coastal wetlands at seven sites around Green

Bay over two summers. Three pairs of otoliths, four pectoral fin rays, a tissue sample, and the stomach were collected for each fish. Age and growth estimates were calculated for all three otoliths and pectoral fin rays. Precision of estimation and von Bertalanffy growth parameters were compared for each structure. Tissue samples were analyzed for stable C and N isotopes to investigate wetland contribution to production and tropic level. These data were compared between sexes and among age classes. This study provides insight into a data deficient predatory species in a highly managed and exploited system. *Keywords: Green Bay, Wetlands, Fish.*

MORRISON, S.[1], JOHNSTON, J.W.[1], JOL, H.[2], KEICHER, P.[2], and LOOPE, W.[3], [1]University of Waterloo, Waterloo, ON, CANADA; [2]University of Wisconsin-Eau Claire, Eau Claire, WI, USA; [3]United States Geological Survey, Munising, MI, USA. **Delineating the subsurface to reconstruct coastal history at sites in Lake Superior and Lake Huron.**

A shallow geophysical technique called ground penetrating radar (GPR) allows researchers to quickly and noninvasively image the subsurface and water table. Our work investigated the coastal stratigraphy and reconstructed the development of two beach deposits using GPR. Using several GPR frequencies we imaged two sandy coastal deposits to depths of tens of meters. Variations in the conductive properties of the sediment relate to changes in sediment and/or water content, guiding the delineation of the internal structure of sediments. The relationship between sediment packages helped define the stratigraphy and reconstruct the sequence of events that built the modern coastal landscape. GPR was used at Grand Island, southern Lake Superior near Munising, MI, and Ipperwash, southeastern Lake Huron near Grand Bend, ON. The upper 4-5 m of sediment at both sites contains a lateral sequence of many ancient shorelines, beach ridges. A preliminary investigation of the topography of the beach ridges suggests deposition within the last 4,500 years. Beach ridges at Grand Island seem to record multi-decadal lake levels within the last millennia, while the beach ridges at Ipperwash record a millennia of multi-decadal lake levels within the last 4,500 years. Waterlain sediments likely lie below the beach ridge package. *Keywords: Lake Superior, Ground penetrating radar, Lake Huron, Coastal processes.*

MUNAWAR, M.[1], MUNAWAR, I.F.[2], FITZPATRICK, M.[1], and NIBLOCK, H.[1], [1]Fisheries & Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7S 1A1, CANADA; [2]Plankton Canada, Burlington, ON, CANADA. **Structure and Function of Lake Ontario Phytoplankton Communities: Long Term Changes, 1970 to 2013.**

Lake Ontario has experienced significant food web alterations during the past four decades including eutrophication, phosphorus abatement, contaminants and invasive species.

Lake wide biological studies began in 1970 but follow up surveys were limited (1978, 1990) until 2003 when the current program (5 year intervals) was adopted. The available data suggests a phytoplankton community in a constant state of flux. For example, mean summer phytoplankton biomass was found to be 6.2 g/m3 during 1970 indicating eutrophic conditions, compared to 1.1 g/m3 in 1978 (oligotrophic), 0.2 g/m3 in 2003 (ultra-oligotrophic), 3.0 g/m3 in 2008 (mesotrophic) and 0.4 g/m3 in 2013 (ultra-oligotrophic). Chlorophyta was the most dominant taxa in 1970 representing about 50% of the total biomass, whereas the assemblage in 2013 contained a mixture of Diatomeae (25%), Cyanophyta (18%) and Chlorophyta (17%) among other taxa. Despite the lower biomass observed in 2013, primary productivity (7.4 mg C/m3/h) has increased significantly over recent years suggesting a more efficient transfer of autochthonous carbon to higher trophic levels. Sampling programs must evolve beyond the current regime of 5 year intervals in order to capture the dynamics of the system. *Keywords: Algae, Trophic state, Photosynthesis, Taxonomy, Biodiversity.*

MUNNO, K.E.[1], HELM, P.[1], JACKSON, D.[1], POIRIER, D.G.[1], BHAVSAR, S.P.[5], CHONG-KIT, R.[1], and PETRO, S.[1], [1]University of Toronto, 33 Willcocks Street, Toronto, ON, M5S 3B3, CANADA; [2]Ontario Ministry of the Environment and Climate Change, 125 Resources Road, Etobicoke, ON, M9P 3V6, CANADA; [3]University of Toronto, 33 Willcocks Street, Toronto, ON, M5S 3B3, CANADA; [4]Ontario Ministry of the Environment and Climate Change, 125 Resources Road, Etobicoke, ON, M9P 3V6, CANADA; [5]Ontario Ministry of the Environment and Climate Change, 125 Resources Road, Etobicoke, ON, M9P 3V6, CANADA; [6]Ontario Ministry of the Environment and Climate Change, 125 Resources Road, Etobicoke, ON, M9P 3V6, CANADA; [7]Ontario Ministry of the Environment and Climate Change, 125 Resources Road, Etobicoke, ON, M9P 3V6, CANADA. **Microplastic Ingestion By Shape in Several Species of Fish from Lake Ontario.**

Microplastics, plastics less than five millimetres in size, come from sources including industry, consumer products and the breakdown of larger plastics resulting in several possible shapes. The anthropogenic origin of microplastics suggest abundance will increase with increasing proximity to major urban centres. Therefore, Lake Ontario is expected to have relatively high abundance of microplastics. To investigate their prevalence in fish digestive tracts relative to the environment, water samples and fish were collected from three sites in Lake Ontario (Humber Bay, Toronto Harbour and Hamilton Harbour) in 2015. Lab-cultured fish were also exposed to microplastics through diet for 24 hours to determine whether ingested microplastics were retained in the digestive tract. Results compare differences in ingestion and excretion relating to shape. Preliminary results indicate that polystyrene spheres and microbeads are ingested and retained at a higher rate relative to

other shapes during 24-hour exposures, and fibres are most prevalent in field-collected fish. This suggests that various forms of microplastics may accumulate in the digestive system of several fish species following ingestion. Accumulation and retention of microplastics may cause physical harm and nutritional issues typically associated with macroplastics.
Keywords: Microplastics, Hamilton Harbour, Fish, Toronto Harbour, Lake Ontario, Humber Bay.

MURPHY, E.W.[1], STAHL, L.L.[2], WATHEN, J.B.[2], SNYDER, B.D.[3], and MCCARTY, H.B.[4], [1]U.S. Environmental Protection Agency, Great Lakes National Program Office, 77 W Jackson Blvd., Chicago, IL, 60604, USA; [2]U.S. Environmental Protection Agency, Office of Science and Technology, William Jefferson Clinton Building 1200 Pennsylvania Avenue, N. W., Washington, DC, 20460, USA; [3]Tetra Tech, 10711 Red Run Blvd., Suite 105, Owings Mills, MD, 21117, USA; [4]CSC Government Solutions LLC, 6361 Walker Lane, Suite 300, Alexandria, VA, 22310, USA. **A Probability-Based Assessment of Contaminants in Great Lakes Fish Fillet.**

In 2010, multiple U.S. EPA offices collaborated to conduct the first probabilistic survey of fish contamination in the Great Lakes. The Great Lakes Human Health Fish Tissue Study added a human health component to the ecological assessments EPA conducted under the statistically designed National Coastal Condition Assessment (NCCA). This study involved collecting one fish composite sample from 157 randomly selected nearshore sites throughout the five Great Lakes. Fillet samples were analyzed for mercury, the full suite of 209 polychlorinated biphenyls (PCBs), 52 polybrominated diphenyl ether congeners (PBDEs), and five omega-3 fatty acids (including EPA or eicosapentaenoic acid and DHA or docosahexaenoic acid). All of the fillet samples contained detectable levels of mercury, PCBs, and PBDEs. Results have been summarized in publications and draft reports and were shared with State and Tribal Agencies. The study is being repeated as part of the 2015 NCCA and will result in the first opportunity to compare probabilistic survey results in the Great Lakes. The 2015 study will incorporate the lessons learned from the previous study (e.g., revision of the target analyte list) and will involve collaboration with colleagues in the Trash Free Waters program at U.S. EPA. *Keywords: Chemical analysis, Human health, Monitoring.*

MURPHY, E.W.[1], SMITH, E.R.[1], CORSI, S.R.[2], VILLENEUVE, D.A.[3], ANKLEY, G.T.[3], EKMAN, D.R.[4], and JORGENSEN, Z.G.[5], [1]Environmental Protection Agency, GLNPO, 77 W. Jackson Blvd., Chicago, IL, 60657, USA; [2]U.S. Geological Survey Wisconsin Water Science Center, 8505 Research Way, Middleton, WI, 53562, USA; [3]USEPA Environmental Effects Research Laboratory, 6201 Congdon Boulevard, Duluth, MN, 55804, USA; [4]USEPA National Exposure Research Laboratory/ORD, 960 College Station Road, Athens, GA, 30605, USA; [5]U.S. Fish and Wildlife Service - Twin Cities Field Office, 4101 American

Boulevard East, Bloomington, Mn, 55425, USA. **An Approach to Define the Impacts of Chemicals of Emerging Concern on Fish and Wildlife Health.**

A substantial increase in the detection of a variety of chemicals / contaminants (C/Cs) of emerging concern (CECs) in the Great Lakes basin has led resource managers to inquire about potential impacts to fish and wildlife health. CECs include an assortment of industrial C/Cs (e.g., flame retardants), agricultural products (e.g., pesticides), materials from urban nonpoint source runoff (e.g. pesticides, plasticizers), and wastewater-related C/Cs. Many CECs are currently unregulated by State and/or Federal water quality programs. Moreover, information about the toxicity of CECs to fish and wildlife is limited, particularly when compared to regulated C/Cs (e.g., legacy contaminants such as organochlorines). In response, a large team of federal and academic partners has been created to address this lack of information in order to better support Great Lakes resource managers. As outlined in a recently developed Strategic Plan, this team is using an integrated three pronged research, monitoring and surveillance approach designed to assess the occurrence of CECs in Great Lakes tributaries and determine their impacts on multiple species as a function of land use, examining both point (e.g., municipal) and non-point (e.g., diffuse agricultural and urban) sources. This approach will be reassessed and amended as needed on a yearly basis.
Keywords: Effects, Chemical analysis, Omics, Environmental contaminants, Ecosystem health.

N

NAGATO, E.G., SIMPSON, A.J., and SIMPSON, M.J., University of Toronto at Scarborough, 1265 Military Trail, Toronto, ON, M1C1A4, CANADA. **Metabolomics Detects Changes in Daphnia magna Exposed to Malathion, Diazinon and Bisphenol A.**

Current toxicity tests typically assess endpoints such as mortality and fecundity. Though simple to conduct, these tests do not provide insight into toxic mechanisms of contaminant stress, especially at sub-lethal concentrations. 1H nuclear magnetic resonance (NMR)-based metabolomics shows promise as a sensitive, high-throughput tool that can provide insight into the mechanisms of sub-lethal toxicity. Using Daphnia magna as a test organism, the response of D. magna exposed over 48 hours to the organophosphates (OPs) malathion and diazinon and the endocrine disruptor bisphenol A was investigated using 1H NMR-based metabolomics. At levels below LC50 values, there were clear perturbations in metabolite concentrations with both OPs. Changes in amino acids as well as glucose and lactate were observed. Overall, there was evidence that D. magna switched to anaerobic energy production and used amino acids for energy. At the highest exposures D. magna

slowed metabolic activity in an effort to mitigate OP stress. The magnitude of these responses was related to the exposure concentrations. Bisphenol A exposures showed similar perturbations, with energy disruption being the major stress indicator. This research suggests that metabolomics can be used to monitor how sub-lethal perturbations may impact the health of aquatic ecosystems. *Keywords: Environmental contaminants, Metabolomics, Water quality, NMR, Crustaceans.*

NAKHAEI, N.[1], BOEGMAN, L.[1], LOEWEN, M.[2], and MEHDIZADEH, M.[2], [1]Queens University, Kingston, On, K7L 3N6, CANADA; [2]University of Alberta, Edmonton, CANADA. **Hydrodynamic and biogeochemical modeling of stormwater ponds.**

Stormwater ponds have been used for decades to mitigate and control the increase in runoff rates that is one of the consequences of urbanization. These ponds retain nutrients, leading to water quality management issues, such as eutrophication. Algae blooms in urban environments pose a threat to public health. In this study, four ponds in the city of Edmonton, with different sizes, depths and surrounding vegetation, have been chosen to investigate the causes of eutrophication. To do so, we apply the hydrodynamic-biogeochemical model ELCOM-CAEDYM, which has also been applied for many modelling studies on the Great Lakes. Unlike lake applications, the hydrodynamic ELCOM simulation required significant adjustment to the bottom drag coefficient, solar radiation and light extinction, to calibrate the model for the surrounding vegetation, shading and light attenuation. Overall, root-mean-square errors are around 2.0. Initial findings from application of CAEDYM to simulate eutrophication will also be presented. *Keywords: Water quality, Storm-water ponds, Algae, ELCOM CAEDYM, Modeling.*

NALEPA, T.F.[1], BALDRIDGE, A.K.[2], GLYSHAW, P.W.[3], RUDSTAM, L.G.[4], and WEIDEL, B.C.[5], [1]Water Center, Graham Sustainability Institute, Unversity of Michigan, 214 S. State St., Ann Arbor, MI, 48109, USA; [2]Great Lakes Environmental Research Laboratory, NOAA, 4840 S. State St., Ann Arbor, MI, 48108, USA; [3]Cooperative Institute for Limnology and Ecosystems Reasearch, University of Michigan, 4840 S. State St., Ann Arbor, MI, 48108, USA; [4]Cornell Biological Field Station, 900 Shackelton Point Rd., Bridgeport, NY, 13030, USA; [5]Lake Ontario Biological Station, USGS, 17 Lake St., Oswego, NY, 13126, USA. **Trends in the Benthic Macroinvertebrate Community in Lake Ontario Through 2013.**

As part of the Coordinated Scientific and Monitoring Initiative (CSMI) in Lake Ontario in 2013, a lake-wide survey was conducted to assess recent trends in the benthic community. Most of the 45 sites were previously sampled at 5-year intervals dating back to the late 1990s. All *Dreissena* collected in 2013 were *D.r. bugensis* (quagga). At depths 31-90 m,

mean densities of *D.r. bugensis* were lower than densities in 2008; mean densities were 6,313/m^2 and 4,723/m^2 in 2008 and 2013, respectively. In contrast, density increased at > 90 m (747/m^2 to 2,000/m^2). Depth-weighted biomass (AFDW) for the entire lake increased from 7.7 g/m^2 in 2008 to 15.5/m^2 in 2013 partly because of the larger size of mussels found in 2013. Declines in *Diporeia* that were first observed in the early 1990s continued; only one individual was collected in 2013. For Oligochaeta, densities at 18-30 m increased 2-fold between 2008 and 2013, but no changes were noted > 30 m. Potentially, this increase could be related to more detrital material in nearshore areas resulting from *Dreissena* activities. Sphaeriidae continued to decline at all depths and no changes were noted in Chironomidae. These changes will be discussed relative to changes in Lakes Michigan and Huron.
Keywords: Benthos, Lake Ontario, Dreissena.

NARINI, M. and KIRKWOOD, A.E., University of Ontario Institute of Technology, 2000 Simcoe St.N., Oshawa, ON, L1H7K4, CANADA. **Water Quality Impacts to Phytoplankton in the Nottawasaga River and Minesing Wetland.**

The Nottawasaga River is the largest tributary discharging into Nottawasaga Bay, Georgian Bay, making it an important contributor to water quality in the nearshore zone. To assess how water quality influences phytoplankton growth in the Nottawasaga river, 15 sites were sampled from June - September 2014. Total algal biomass was significantly correlated with total suspended solids (TSS) during the months of June (r2=0.63) and September (r2=0.74), while total chlorophyll a (CHL) did not show significant (P>0.05) correlations during the sampling period. Total phosphorus, though strongly correlated with TSS (r2=0.70), was not significantly correlated with total algal biomass, CHL or dominant algal genus biomass. Canonical correspondence analysis showed distinct community and water quality profiles between the first upstream site and sites downstream of the confluence with Innisfil Creek. Most downstream sites were highly similar with respect to community structure. River turbidity, more so than nutrients, appears to be an important controlling factor of phytoplankton community structure and biomass, resulting in community homogenization throughout the lower Nottawasaga River. *Keywords: Watershed, Monitoring, River, Phytoplankton, Water quality, Land-use.*

NEMETH, N., CAMPBELL, D., SHIROSE, L., OESTERLE, P., MCEWEN, B., and JARDINE, C., Canadian Wildlife Health Cooperative, 419 Gordon Street, Guelph, ON, CANADA. **The Red Fox (*Vulpes vulpes*) as a Potential Sentinel for Blastomyces dermatitidis in Ontario, Canada.**

Blastomyces dermatitidis is a fungal pathogen that can lead to fatal infections in humans and other animals. Infection usually occurs via inhalation of fungal spores from an environmental reservoir, often soil. Infection rates and associated disease (blastomycosis) are relatively high in humans and dogs along the Great Lakes and other major waterways. However, the geographic distribution of B. dermatitidis is difficult to determine because the fungus is not readily recoverable or uniformly distributed within the environment. Widely distributed and common wild canid species, such as the red fox (Vulpes vulpes), are susceptible to infection with B. dermatitidis, have relatively small and well-defined home ranges, and live in close contact with the soil. We performed a retrospective study of wild and domestic canids diagnosed with blastomycosis at the Canadian Wildlife Health Cooperative and Animal Health Laboratory in Ontario. Although dogs were much more commonly diagnosed with blastomycosis, the timing, geographic distribution, and extent of fungal-induced lesions in red foxes suggested that this species could serve as a potential sentinel for environmental risks of B. dermatitidis that threaten public and animal health.
Keywords: Fungal Pathogen, Blastomyces dermatitidis, Great Lakes basin, Canines.

NI, F., KELLY, N.E., PERHAR, G., and ARHONDITSIS, G.B., University of Toronto Scarborough, Department of Physical & Environmental Sciences, 1265 Military Trail, Toronto, ON, M1C 1A4, CANADA. **Toward the Development of An Ecophysiological Daphnia Model to Examine Toxicity and Nutrition.**

Despite efforts to address issues of mercury (Hg) in the environment, levels continue to rise. Freshwater ecosystems are highly susceptible to Hg deposition, which impacts biotic health and leads to serious consequences through biomagnification. Daphnia, a key component in freshwater systems, links autotrophs to higher trophic levels and can serve as an indicator of aquatic health. Combined with metabolomics, the study of metabolites and their chemical processes, we have developed a model that attempts to elucidate the interactive effects of Hg toxicity and nutrition on phytoplankton-Daphnia relationships. Our model stipulates a physiological hierarchy, prioritizing different physiological processes in the order of neurological functions, bio-energetics, osmoregulatory maintenance, waste management, and growth investments. Daphnia resiliency is controlled by both food quantity and quality and each physiological process is modulated by the somatic levels of different metabolites. By enriching food with congeners associated with neurological and energetic enrichment (e.g., phosphorus, tryptophan), effects of toxicity can be countered. Our work highlights that healthy dietary patterns can be critical in ameliorating toxicity, and therefore biotic populations cannot be maintained solely through contaminant management.
Keywords: Mercury, Metabolomics, Toxic substances, Nutrition, Trophic level, Zooplankton.

NIBLOCK, H.[1], MUNAWAR, M.[1], FITZPATRICK, M.[1], and RUDSTAM, L.G.[2], [1]Fisheries and Oceans Canada GLLFAS, 867 Lakeshore Rd, Burlington, ON, L7S 1A1, CANADA; [2]Cornell University, Ithaca, NY, USA. **Assessing Phytoplankton Community Tends in Lake Ontario: Index Stations vs. Spatial Surveys.**

When studying phytoplankton dynamics in large lakes, the costs and logistics involved usually prohibit frequent lakewide sampling. As a consequence, seasonal processes are poorly understood. The obvious tradeoff is to sample more frequently at a limited number of stations representing regions of the lake and ignore spatial variability. Both sampling strategies were deployed in Lake Ontario's 2013 Coordinated Science and Monitoring Initiative by Canadian and American researchers. This included 4 lakewide surveys and bi-weekly sampling at 3 index stations (May-Oct). Lakewide average phytoplankton biomass ranged from 0.14 g m 3 in April to 0.43 g m 3 in July compared to 0.05 - 0.72 g m 3 at the eastern index station. Similarly, lakewide primary productivity averaged 1.9 mg C m-3 h-1 in April to 7.4 mg C m-3 h-1 in August and was similar to the range of 1.2 to 10.8 mg C m-3 h-1 observed at the index station. This paper will provide examples of both strategies and consider their relative merits with respect to the phytoplankton community of Lake Ontario. *Keywords: Lake Ontario, Phytoplankton, Monitoring.*

NORTON, R.K., University of Michigan, 2000 Bonisteel Blvd., Ann Arbor, MI, 48109, USA. **Public Trust Duties, Liabilities, Powers, and Constraints Along Laurentian Great Lakes Shores.**

All of the Great Lakes states have adopted the "public trust doctrine" for their Great Lakes waters (Norton et al., 2011). Under that doctrine, each state owns lands submerged by Great Lakes waters, and it holds a property interest--either fee ownership or a public trust interest--in shorelands up to the "ordinary high water mark" (OHWM) along its Great Lake shorelines. Great Lakes shorelines are distinct from ocean shorelines, however, given long-term fluctuations in lake standing water levels. Given that unique attribute, incorporation of the public trust doctrine, which originated under Roman law along tidal ocean coasts, has created unique planning, policy, and legal issues that none of the Great Lakes states has yet fully contemplated. Moreover, while legal scholars have begun to address the public trust duties and liabilities of coastal states given global climate change (e.g., Wyman 2010; Tarlock 2012), none has fully explored state and local duties, liabilities, powers, and constraints along Great Lakes shores given the unique attributes of Great Lakes shoreline dynamics. This paper provides a first cut analysis of those issues. *Keywords: Shore protection, Policy making, Water level fluctuations, Public trust doctrine, Planning.*

NOWICKI, C.J.[1], ARMENIO, P.M.[3], CAVALETTO, J.F.[2], RUTHERFORD, E.S.[2], VANDERPLOEG, H.A.[2], MAYER, C.M.[1], WARNER, D.M.[3], and BUNNELL, D.B.[3], [1]University of Toledo, 2801 Bancroft Street, Toledo, OH, 43606, USA; [2]NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Road, Ann Arbor, MI, 48108, USA; [3]USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105, USA. **To eat or be eaten? The Ups and Downs of Zooplankton Diel Vertical Migration in Lake Huron.**

Planktivorous invertebrates (e.g., *Mysis*, *Bythotrephes*) and fish influence the community composition and production of zooplankton, yet few studies have described the vertical distribution of zooplankton and their predators during day and night. In 2012, we conducted day and night sampling of zooplankton, their predators, their food, and other abiotic factors to improve understanding of zooplankton diel vertical migration (DVM) patterns. Sampling occurred monthly from July through October 2012 at Thunder Bay and Hammond Bay, Lake Huron at two sampling depths (46m and 82m). Layered zooplankton tows were collected with a closing 64 µm mesh net and DVM was calculated for fourteen species. We used multiple linear regressions models to examine the relative influence of planktivore biomass (*Bythotrephes*, *Mysis*, and fish), temperature and distance to food (i.e., chl a) on zooplankton DVM. Results showed that six species undergo significant DVM ($p < 0.05$), and *Mysis* biomass and temperature were the primary explanatory factors affecting zooplankton DVM in Lake Huron. Our unique approach of investigating the effects of whole ecosystem variables on zooplankton DVM in Lake Huron facilitates further understanding of changes in food web dynamics in the Great Lakes *Keywords: Zooplankton, Diel vertical migration, Distribution patterns, Bythotrephes, Lake Huron, Mysis.*

NUDDS, T.D.[1] and REID, K.B.[2], [1]University of Guelph, 50 Stone Road E, Guelph, ON, N1G 2W1, CANADA; [2]Ontario Commercial Fisheries' Association, 45 Jame St., Blenheim, ON, N0P 1A0, CANADA. **The DAAM Project for Great Lakes Fisheries: Evolution of an Academic-Industry-Government Partnership.**

Increasingly, the role of science in the management of natural resources acknowledges the importance of stakeholder engagement in decision making processes. Crises of confidence in the management of commerial fisheries on Lakes Huron and Erie catalyzed an industry-led research initiative, the Decision Analysis and Adaptive Management (DAAM) Project for Great Lakes Fisheries. This introduction to the session will review the genesis, evolution and products of the DAAM Project since its inception in 2003 and the first presentaion about the DAAM Project at IAGLR. Until 2010, research was solely funded by industry, and since, by industry and a national Canadian Fisheries Research Network (CFRN) funded NSERC Strategic Networks Grant. Students and postdoctoral fellows involved in the "Great Lakes node" of the CFRN will summarize contributions and implications for managing for sustainability of socio-ecologically complex fisheries. *Keywords: Fish management, Lake Erie, Political aspects.*

NUMMER, S.A. and QIAN, S.S., University of Toledo, Wolfe Hall 1235 2801 West Bancroft St. Mailstop #604, Toledo, OH, 43606-3390, USA. **Effect of Conservation Practices on Agricultural Nutrient Loss.**

Nitrogen and phosphorus runoff from agricultural lands and the subsequent impact on water quality has been of great interest in the United States, due to harmful algal blooms and anoxic zones in areas such as Lake Erie and the Gulf of Mexico. Conservation practices have been widely used to reduce the amount of nutrients leaving a field, but there is a lack of research on how effective these practices are. Our objective is to quantify the effect of conservation practices on nitrogen and phosphorus runoff in farmlands. A meta-analysis was conducted using the Measured Annual Nutrient loads from AGricultural Environments (MANAGE) database created by the USDA-ARS. MANAGE is a compilation of 65 publications including data on nitrogen and phosphorus loads, runoff, land use, fertilizer application, and other field characteristics. The observational nature of the dataset makes direct comparisons from field to field unreliable. To quantify the effect of conservation practices on nutrient loss we used propensity scores and multilevel modeling, two statistical methods common for observational data. Propensity score matching shows that conservation practices have a significant reduction of 67.5% in total phosphorus, 83% in particulate phosphorus, and 67.3% in particulate nitrogen. Multilevel modeling results support these findings. *Keywords: Mathematical models, Agriculture, Nutrients.*

NURNBERG, G.K.[1], HOWELL, E.T.[2], and PALMER, M.E.[2], [1]Freshwater Research, 3421 Hwy 117, Baysville, On, P0B 1A0, CANADA; [2]ON Ministry of the Environment and Climate Change, 125 Resources Road, Toronto, ON, M9P 3V6, CANADA. **The Potential Impact of Central Basin Hypoxia and Internal Loading on North Shore Water Quality.**

We hypothesized that north shore water quality of Lake Erie's Western and Central Basins is impacted by Central Basin hypoxia and related internal phosphorus (P) loading. First, we quantified Central Basin hypoxia from published information of annual hypoxic (<2.0 mg/L dissolved oxygen) areal extent and duration as hypoxic factor (HF, the number of days in Aug-Sep that a sediment area equal to the Central Basin surface area was hypoxic). 1985 to 2012 HF values averaged 15.2 d/yr and ranged between 0 (1996) and 34.3 d/yr (2012, year of extended fishkill along the north shore). Internal load was estimated from an

areal release rate multiplied by HF and averaged 122 $mg/m^2/yr$ for 1985-2012. Second, we analyzed phosphorus (P) and chlorophyll (chl) data at 2 north shore sites, Leamington (Western) and Port Stanley (Central) provided by the Great Lakes Intake Program. Central Basin HF and internal loading were significantly correlated with summer dissolved reactive P and Aug-Oct chl concentrations at Port Stanley, but not Leamington. These correlations may be causal because summer Central Basin hypolimnetic currents are directed towards the north shore. They support our hypothesis that Central Basin north shore water quality is impacted by Central Basin hypoxia. *Keywords: Lake Erie, Hypoxia, Nutrients, Internal P loading, Littoral zone, Chlorophyll.*

O

O'NEILL, C. and MELZER, R., Ontario Ministry of the Environment and Climate Change, 135 St Clair Ave W, 6th floor, Toronto, ON, M4V1P5, CANADA. **New frameworks for collaborative governance under Ontario's Great Lakes Protection Act, 2015.**

In November 2015, Ontario's Great Lakes Protection Act, 2015, came into effect. The legislation creates new frameworks for collaboration among partners and sectors; new governance mechanisms to support action on Great Lakes priorities; and new transparency and reporting requirements. The purposes of the law are both wide-ranging and specific: they span social, economic and environmental concerns, and include a suite of priority ecosystem elements, geographic areas, and stressors. The legislation establishes requirements for Great Lakes performance measures, indicators of ecological health, triennial reporting, and target-setting. It creates new mechanisms for collaborative action, which include enshrining Ontario's Great Lakes Strategy. Under the Act and Strategy, work is implemented in partnership with key stakeholders, and builds on binational and sub-national agreements and also science. Selected highlights of Ontario's first triennial progress report on Great Lakes will also be presented. *Keywords: Policy making, Governance, Management.*

O'REILLY, K.E.[1], MCREYNOLDS, A.T.[1], STRICKER, C.A.[2], and LAMBERTI, G.A.[1], [1]University of Notre Dame, 292 Galvin Life Sciences Building, Notre Dame, IN, 46556, USA; [2]U.S. Geological Society, Denver Federal Center Building 95, MS963, Denver, CO, 80225, USA. **Quantifying Lake Michigan Coastal Wetland-Nearshore Linkages For Sustaining Sport Fisheries.**

Movement of energy and organisms between highly productive Great Lakes coastal wetlands and adjacent nearshore habitats represents a critical, but largely unstudied, ecological linkage. We hypothesized that use of wetlands as spawning, rearing, and foraging habitat by native sport fishes, including yellow perch (*Perca flavescens*), represents a potentially vital linkage with the nearshore that contributes to high fish production and diversity. We collected sport fish and potential prey items for stable isotope and otolith microchemical analyses from nine paired wetland-nearshore sites across Lake Michigan in 2014 and 2015. Isotope data indicate that wetland trophic pathways are distinct from nearshore pathways, with wetland dissolved inorganic carbon $\delta^{13}C$ being -7.3‰ more depleted on average. Preliminary water chemistry data indicate that otolith Mn and Fe may provide the best discrimination between habitats. Our estimates of cross-habitat linkages will fill a major data gap concerning how sport fish utilize diverse habitats during different periods of their life history. Improved understanding of habitat usage will provide managers with tools for prioritizing preservation and restoration efforts in Lake Michigan to enhance sport fish recruitment and production. *Keywords: Coastal wetlands, Fish, Lake Michigan.*

ODEGARD, J.L., GRAY, S.M., and PINTOR, L.M., School of Environment and Natural Resources, The Ohio State University, 2021 Coffey Rd., Columbus, OH, 43201, USA. **The Role of Functional Diversity in Biotic Resistance of Exotic Fishes and Invertebrates in Wetlands.**

Biological invasions are a leading cause of declines in biodiversity and impairment of ecosystem function. Native communities that resist invasion from exotic species (i.e. biotic resistance) are frequently found to be more diverse in small-scale studies. Research examining biotic resistance (i.e. diversity-invasibility relationship) has typically focused on measuring taxonomic biodiversity (e.g. species richness). However, functional diversity (e.g. trophic diversity) might also be an important factor contributing to biotic resistance because it more accurately reflects temporal and spatial environmental constraints and competition for resources within the system. We investigated the role of functional compared to taxonomic diversity in biotic resistance in fish and macroinvertebrate communities in Lake Erie coastal wetlands. Seasonal sampling between 2013 and 2015 across 10 sites in the Ottawa National Wildlife Refuge yielded variation in diversity among fish and aquatic macroinvertebrate communities. Our initial examination of collected data indicates 12% of fish are exotic (42 total species). Natives and exotics overlap in 50% of observed trophic groups (6 total); potentially indicating a role for competition. Findings from this study will be important for identifying community characteristics that allow biotic resistance.
Keywords: Biodiversity, Lake Erie, Invasive species.

ODENBRETT, G.C. and NEFF, F., Case Western Reserve University, 10900 Euclid Avenue, Cleveland, Oh, 44106, USA. **Undergraduate Engagement in Great Lakes Restoration, Research, and Stewardship: GLISTEN.**

Undergraduate environmental service-learning activities benefiting public and private non-profit environmental organizations can serve as a powerful form of civic engagement that significantly enhances learning in courses based on SENCER principles. GLISTEN, the Great Lakes Innovative Stewardship Through Education Network, exemplifies these principles applied to community-based undergraduate research on, and restoration and stewardship of, the Great Lakes ecosystem. The goals of this session are to provide participants with an overview of best practices in course-based environmental service learning incorporating these activities. The presenters will provide robust examples of how Great-Lakes-ecosystem-focused environmental service-learning has enriched undergraduates' learning in the science, engineering, and general education curricula, while significantly enhancing the capacity of community-based environmental organizations to engage in much-needed Great Lakes research, restoration, and stewardship. The unique GLISTEN student leadership model will also be featured. Attendees will have the opportunity to begin developing environmental service-learning activities to be integrated with undergraduate coursework on their own campuses, and will be provided with access to resources to continue the process after the conference. *Keywords: Environmental education, Undergraduate education, Watersheds, STEM education, Service-learning.*

OLSAVSKY, M.J., CARNICOM, C., SCHMIDT, K.L., and MINESKY, J.J., Lourdes University, 6832 Convent Boulevard, Sylvania, OH, 43560, USA. **Creating Synergies for Great Lakes Ecosystem Restoration & Sustainability Via Undergraduate Courses.**

Today in the Great Lakes region, every dollar, staff hour and volunteer hour matter when addressing the region's complex challenges. Therefore, creating synergies between higher education and community partners, such as government agencies and nongovernmental organizations, can be vitally important in restoration projects and sustainability efforts. Faculty and undergraduate students at Lourdes University, a small liberal arts university in the Ottawa River watershed in northwest Ohio, integrate science courses, service learning, partnership development, sustainability policy, and student research, design, and leadership to assist partners with local ecological restoration and sustainability. Using the model developed by GLISTEN (Great Lakes Innovative Stewardship Through Education Network), undergraduate stewardship liaisons (USLs) have been integral partners in organizing service learning opportunities in science courses. Service learning and restoration-related projects in certain courses help to facilitate undergraduate learning, to enable students to become more engaged in restoration and sustainability efforts being conducted by community partners, and to contribute to local restoration and sustainability in synergistic ways. Students use their experiences with community partners to then develop projects on campus. *Keywords: Restoration, Sustainability, Service learning.*

ORTIZ, J.D.[1], AVOURIS, D.[1], BULLERJAHN, G.S.[2], MCKAY, R.M.[2], LUVALL, J.C.[3], and SCHILLER, S.[4], [1]Kent State University, Dept. of Geology, Kent, OH, 44242, USA; [2]Bowling Green State University, Dept. of Biological Sciences, Bowling Green, OH, 43403, USA; [3]NASA MSFC NSSTC, Applied Science Team, Huntsville, AL, 35804, USA; [4]South Dakota State Univ., Dept. of Physics, Brookings, SD, 57007, USA. **Optical differentiation of algal toxicity and its correlation with microcystin in Sandusky Bay, Lake.**

The cyanophytes associated with the CyanoHABs in Lake Erie and Sandusky Bay (Microcystis and Planktothrix) are both capable of producing the hepatotoxin microcystin, which is considered dangerous above 1 ppm. Remote sensing methods can be used as a "first look" method to guide collection of samples for toxin analysis by traditional methods for verification. However, chlorophyll a and phycocyanin are not diagnostic indicators of microcystin. We present a remote sensing method that can differentiate potentially toxic from non-toxic phytoplankton and cyanophytes through the complex pigment assemblages that presumably develop in response to differing environmental and ecological conditions. To test the method, samples were collected along a transect from Muddy Creek in Sandusky Bay toward Avon Point. By application of visible derivative spectroscopy to statistically decomposed visible hyperspectral data, we differentiate and quantify the relative proportion of various cyanophyte and algal components associated with the Sandusky bloom. The assemblages can then be related to the concentration of microcystin measured in coincident samples. The result of this initial test was favorable, producing a statistically significant correlation of r^2 ~0.7 between the optical estimate of algal composition and toxin concentration. *Keywords: Harmful algal blooms, Toxic substances, Satellite technology.*

OSMOK, J.[1] and AULENBACK, D.[2], [1]Dufferin and South Simcoe Stewardship Network, 2284 Nursery Rd., Midhurst, ON, L0L1X0, CANADA; [2]Ontario Ministry of Natural Resources and Forestry, Aurora District, 50 Bloomington Rd., Aurora, ON, L4G 0L8, CANADA. **Lake Simcoe & South Eastern Georgian Bay Community Stewardship Program.**

The Lake Simcoe Basin is home to 360,000 people; approx. 12,000 properties located along the Lake's shoreline and the remainder throughout urban, suburban and rural areas. The diversity of the watershed and shifting landscape activities/practices contribute to stressors on the watershed ecosystem and lend credibility to stewardship approaches that evoke change in behaviour and adoption of environmental Best Management Practices. The Lake Simcoe & South Eastern Georgian Bay Community Stewardship Program is a holistic, educational, and incentive based program targeting rural, shoreline and agricultural landowners. The program uses workshops to introduce landowners to geographically specific stewardship guides and encourages them to undertake a self-evaluation of environmental risk with their properties. Landowners are encouraged to implement environmental improvements that address priority issues impairing water quality and aquatic habitat conditions in the watershed. Landowners are supported through access to financial incentives, resource/ information and technical support. The programs self-evaluation and guide-based approach has been an effective model in facilitating high landowner participation and in identifying priority projects where linked with financial incentives and technical support provisions. *Keywords: Cleanup, Georgian Bay, Education, Lake Simcoe.*

OSTER, B.T.[1] and CHUTKO, K.[2], [1]Nipissing University, North Bay, ON, CANADA; [2]Department of Geography and Planning, University of Saskatchewan, Saskatchewan, SK, CANADA. **Mapping Sedimentary Phosphorus Sources in a Great Lakes Headwater Watershed.**

Algal blooms are becoming more frequent in headwater watersheds of the Great Lakes. Phosphorus (P) is a main contributor to algal growth in fresh water lakes (Schindler et al., 2008). This research, focusing on Callander Bay on Lake Nipissing and upstream Wasi Lake, examines spatial differences of sedimentary phosphorus availability to attempt to identify sources of internal nutrient loading. Cores were taken in late September and early October 2015 from spatially significant sites throughout the lakes with the upper 5cm of sediment analyzed for iron (Fe)-bound, aluminum (Al)-bound, and total P (TP) following a sequential extraction methodology similar to Nurnberg (1988). The results on Callander Bay showed an average of 0.042, 0.039, and 4.192 mg/g of P for Fe-bound, Al-bound, and TP respectively. Wasi Lake had higher averages of 0.076, 0.055, and 5.595 mg/g of P for Fe-bound, Al-bound, and TP respectively. Average dissolved oxygen levels of 6.48 mg/L at Callander Bay and 6.27 mg/L at Wasi Lake during sediment collection are above anoxic conditions. Seasonal buoy data showed anoxia prior to sediment collection from Callander Bay, however there was no dissolved oxygen data from Wasi Lake. Identifying sources of P can assist in focusing efforts to eliminate or reduce inputs and potentially the occurrence of algal blooms. *Keywords: Phosphorus, Sediments, Algae.*

OVEISY, A., SHE, Y., and LOEWEN, M., Department of Civil & Environmental Engineering, University of Alberta, 9211 - 116 Street NW, Edmonton, AB, T6G 1H9, CANADA. **Numerical modeling of ice cover on stormwater ponds.**

Storm water storage facilities are used to control the quality and quantity of excess runoff. Many of these ponds are located in residential areas and are popular for recreational use. In the summer, the recreational use depends on quality of water. In winter, the thickness of the ice over the ponds is the main concern for recreational uses such as skating, hockey and broomball. The thickness of ice in these ponds can vary rapidly, for example in some of the City of Edmonton (AB, Canada) ponds ice covers as thick as 30 cm have been observed to melt in less than 24 hours. Numerical modelling, supported by field observations, is an effective tool for prediction of ice thicknesses. In this study we use ELCOM-Ice, (Oveisy et al., 2012) to model ice formation on an Edmonton stormwater pond. The study pond has a surface area of ~2.2 Hectares. Two inlets bring runoff to the pond and one outlet drains the pond. Temperature profiles sampled at four locations in the pond for the winter period of 2013-2014, were used as initial conditions as well as for validation of the model predictions. Manual and ground penetrating radar ice cover thickness measurements during modeling period are compared with the model results. *Keywords: Ice, Stormwater pond, Model studies, ELCOM.*

P

PADOVAN, P.M.[1], COCKBURN, J.M.H.[1], and VILLARD, P.V.[2], [1]Department of Geography University of Guelph, Guelph, ON, CANADA; [2]GEO Morphix Ltd., Milton, ON, CANADA. **Hydrogeomorphic Adjustment in Urban Hybrid Channel Restoration Projects.**

Climate variability and landuse change are degrading urban streams around the Great Lakes. Extreme runoff and more frequent bankfull events accelerates degradation as climate change persists. Hybrid restoration techniques are often used in urban watersheds where natural channel design applications are limited by urban constraints. This study assessed the performance and adjustment mechanisms that occurred within urban hybrid restoration projects along Highland Creek, a heavily urbanized area in the east end of Toronto, Ontario, Canada. Highland Creek has no stormwater management systems in place, which drastically affects water conditions during storms and can transfer sediments and nutrients into Lake Ontario. The current state of design features and adjustment mechanisms were surveyed in 2015 along six restored reaches of Highland Creek and historical photo analysis was used to analyze planform stability. Findings show that reaches continue to experience adjustment 15

years post construction. The most commonly observed adjustments included bed adjustment within riffle structures, degradation exposing parent material, and evidence of channel widening. This study contributes to our understanding of urban restoration success and can be used as an example for similar projects in urban watersheds throughout the Great Lakes. *Keywords: Urban areas, Restoration, Hydrogeomorphology, Urban channels, Tributaries.*

PAIGE, K.K. and SCHRADER, K.L., Great Lakes Observing System, 229 Nickels Arcade, Ann Arbor, MI, 48104-2409, USA. **Cultivating a Data Community to Maximize Potential of the Great Lakes Observing Enterprise.**

Designing a regional observing system for the Great Lakes first started to take shape in 2003 when a steering committee was formed with representatives from federal, state, and regional agencies, organizations, and academic institutions, led by the Great Lakes Commission and supported by funds from NOAA. This founding group would go on to establish the Great Lakes Observing System (GLOS), which now operates as an independent 501(c)3, dedicated to connecting providers and users of data and information in the Great Lakes/St. Lawrence River basin in ways that support management and decision-making. GLOS has worked to establish and fine-tune its role in the region among a diverse network of stakeholders that collect, analyze, deliver and use data. Now ten years since the first independent board meeting, GLOS looks to mature its position in the region as coordinator, integrator, and point of leverage and discovery that serves the data needs of the Great Lakes. Cultivating a data sharing community with a culture of involvement and common goals will be an ongoing guiding principle as GLOS continues to connect and grow an otherwise disparate network of observing and data initiatives. This presentation will provide an overview of the evolution of the GLOS network and future plans for improved coordination and partnership. *Keywords: Data storage and retrieval, Data acquisition, Monitoring.*

PALMER, C.J.[1], AMOS, M.M.[1], STAPANIAN, M.A.[2], LEWIS, T.E.[3], FEVOLD, B.M.[1], WALTERS, L.[1], BLUME, L.J.[4], and RODRIGUEZ, K.[4], [1]CSRA, Alexandria, VA, 22310, USA; [2]U.S. Geological Survey, Sandusky, OH, 44870, USA; [3]U.S. Army Corps of Engineers, Vicksburg, MS, 39180, USA; [4]U.S. EPA, Chicago, IL, 60604, USA. **Establishing Measurable Quality Objectives for Assessing Ecological Monitoring Variables.**

The collection of ecological data for monitoring presents many challenges. In particular, ecological variables requiring data collection based on observations and best professional judgment by field personnel can be difficult to obtain in an accurate and reproducible manner. An interagency committee has been developing quality assurance guidance to assist ecologists with strategies for maximizing the quality of data generated under monitoring programs for ecological restoration projects such as those funded by the Great Lakes Restoration Initiative. A critical planning step is to select quantitative objectives for indicators of data quality such as precision, bias or and accuracy. These objectives are then used as guidelines to train and certify field crews, implement quality control, and undertake quality assessment during data collection efforts. Examples will be provided to demonstrate a process for developing quality objectives that are measurable. Conference attendees are encouraged to test this process with their projects and provide feedback and suggestions to the committee. *Keywords: Great Lakes Restoration Initiative, Data acquisition, Quality assurance, Biomonitoring, Ecosystems.*

PALTSEV, A.I. and CREED, I.F., Western University, Richmond Street, London, ON, N6A 3K7, CANADA. **Exploration of spatial and temporal changes in chlorophyll a of lakes in Ontario.**

Phytoplankton blooms are on the rise in the lakes of North America; however the fundamental question what factors contribute to the blooms has remained unanswered. To examine the influence of internal (lakes-specific) vs. external (climate and landscape properties) factors on lake phytoplankton (1)a regression model that relates chlorophyll a (chl-a) to Landsat TMETM+ optical reflectance was developed for central Ontario and (2) two-way ANOVA that defines three types of variation (spatial, temporal, and space & time interaction) in chl-a was applied. Reflectance in Landsat band 3 showed the strongest correlation with in situ data explaining 85% of variance in chl-a(p0.001). Application of the regression model allowed to build a continuous survey of chl-a in 6,410 lakes for 28 years. Application of ANOVA revealed that internal type of variation (spatial & temporal interaction) explained the majority of the variance in chl-a (75%) for the study region. However, when the region was segregated into sub-regions (watersheds), a much larger proportion of the variance (50% for 11 out of 12 watersheds) was related to external types (space and time). This suggests that the influence of external factors on chl-a is more pronounced within regions that are relatively hydrologically homogeneous (watersheds) and not spatially extensive *Keywords: Lake model, Remote sensing, Phytoplankton.*

PANJABI, K.G.[1], RUDRA, R.P.[1], GHARABAGHI, B.[1], and GOEL, P.[2], [1]University of Guelph, Guelph, ON, USA; [2]Ontario Ministry of the Environment and Climate Change, Etobicoke, ON, CANADA. **Incorporation of Variable Source Area Runoff Generation Mechanism into the Hydrology of the AGNPS Model.**

In this study a modeling approach was developed using an event-based distributed Agriculture Non-Point Source Pollution (AGNPS) model to simulate and locate the runoff generating areas based on VSA hydrology concepts. The modeling approach of the AGNPS model was modified to distribute runoff generating areas in a way consistent with VSA hydrology by incorporating the Topographic Wetness Index (TWI). The developed AGNPS-VSA model was validated on a small agricultural watershed in Ontario, Canada. The modified model, AGNPS-VSA showed good agreement with observed runoff and runoff source areas were correctly identified. The developed approach has good potential for applications in agricultural watersheds to develop strategies to minimize the pollutant loads to the surface water bodies by accurately predicting the locations of critical runoff generating areas for application of best management practices.

PATE, J.A. and MCKINNON, E.E., Exxpedition Great Lakes, Bayfield, ON, CANADA. **Studying Microplastics in the Great Lakes: A Citizen Science Model.**

It is well known that the Great Lakes are suffering from considerable microplastic contamination. Despite this awareness, citizens around the lakes struggle to move from knowledge of the problem to action. The solutions for microplastics will in large part come from changes in consumer behaviour, stopping contamination at the source. Exxpedition Great Lakes is an initiative to bring the science of microplastics to the average person, to allow them to see first hand the presence and impact of this pollution in their communities. Citizen scientists will be guided through water sampling and trawling by teams of experienced scientists, on board vessels traveling in the Great Lakes and St. Lawrence River. Other volunteers can participate by exploring and conducting water sampling and cleaning shorelines. The samples taken will be studied by organizations and the results shared with the participants and general public. By experiencing the issues first hand, it is our belief that people will no longer be able to look away from the problems. This first hand experience will lead to changes in behaviour and attitudes, and will instill a sense of a Duty to Care for this precious resource. *Keywords: Microplastics, Environmental education, Public participation.*

PATERSON, G.[1], DROUILLARD, K.G.[2], DIPIERDOMINICO, L.L.[2], and HAFFNER, G.D.[2], [1]State University of New York College of Environmental Science & Forestry, 1 Forestry Drive, Syracuse, NY, 13210, USA; [2]University of Windsor, Great Lakes Insititute for Environmental Research, 401 Sunset Avenue, Windsor, ON, N9B3P4, CANADA. **Ecological Tracers Indicate Basin Specific Ecologies for the Lake Huron Food Web.**

Lake Huron has experienced substantial ecological change in the past decade but little known of how these have become 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: Lake Huron, Stable isotopes, Food chains.*

PAUFVE, M.R.[1], RUDSTAM, L.G.[1], WATKINS, J.M.[1], and WEIDEL, B.C.[2], [1]Cornell Biological Field Station, 900 Shackelton Point Road, Bridgeport, NY, 13030, USA; [2]USGS Lake Ontario Biological Station, 17 Lake Street, Oswego, NY, 13126, USA. **Compiling 50 Years of Data for Lake Ontario: Collaborative Data Management and Historical Trends.**

Binational government agencies and educational institutions have produced a wealth of spatially-referenced limnological data for Lake Ontario dating back to the 1960's. These data sets reside in separate locations, are in a variety of incompatible formats and may not be inaccessible to managers and other potential users. A project funded by the Great Lakes Observing System (GLOS) was initiated with the objectives of 1) working with data holders to promote data sharing, 2) coalescing disparate data sets, including water column profiles (temperature, dissolved oxygen, pigment fluorescence and other parameters), zooplankton communities and biomass, and concentrations of chlorophyll and nutrients into consistently formatted databases and 3) making these databases discoverable, accessible, documented and usable. This will enable managers to place observations, including those from the Cooperative Science and Monitoring Initiative (CSMI) intensive field season in 2013, within a historical context and on a lake-wide scale. Products derived from compiled databases include long-term trends in lake-wide water temperature profiles, thermal stratification and deep chlorophyll layer dynamics and seasonal and spatial distribution of zooplankton communities. *Keywords: Spatial distribution, Data sharing, Zooplankton, Data management, Lake Ontario, Temperature profiles.*

PAWLOWSKI, M.B., University of Minnesota Duluth, 1035 Kirby Drive, Duluth, MN, 55812, USA. **Lake Superior zooplankton community trends and the roles of climate change and invasive species.**

Lake Superior has experienced species introductions and rising average surface temperatures in recent decades. It is unclear how these changes have or will influence the zooplankton community. I compared biomass estimates, community compositions, and phenologies of the zooplankton communities during 2014 and 2015 to historic zooplankton surveys to determine whether variation was part of short or long-term trends. Variability in biomass and phenology was apparent between 2014 and 2015. Some shifts in community composition between decades appear to have occurred including reduced *Bosmina* densities and might be linked to the establishment of the invasive predatory cladoceran *Bythotrephes longimanus*. To explore this possibility, I compared estimates of zooplankton production to consumption by *Bythotrephes*. On average, consumption by *Bythotrephes* did not exceed total zooplankton production in Lake Superior during 2014 or 2015, but seasonally approached or exceeded cladoceran production. Community shifts due to *Bythotrephes* may become more pronounced if *Bythotrephes* abundance and climate change positively interact. This work informs future zooplankton research in Lake Superior and helps to clarify how climate change and invasive species might influence the lake food web. *Keywords: Zooplankton, Climate change, Lake Superior, Invasive species.*

PEARCE, N.J.T. and YATES, A.G., Western University & Canadian Rivers Institute, 1151 Richmond Street, London, On, N6A 5B7, CANADA. **Seasonal Variation of Agricultural Best Management Practice Effects on Stream Water Quality.**

Seasonal variation may influence the ability of best management practices (BMPs) to mitigate effects of agricultural pollutants on water quality. Our goal was to assess seasonal variation in mitigation effects of BMPs by examining the association between instream nutrients and the abundance and location of three BMPs over a hydrologic year. Water samples were collected every 4-weeks from November 2013 to October 2014 in 15 headwater streams representing a gradient of BMP use in Southern Ontario, Canada. Partial least squares (PLS) regression models were used to associate instream nutrient concentrations with the abundance and location of BMPs for each season during the hydrologic year. BMP metrics in PLS models were able to predict instream concentrations of phosphorus species and ammonium, but could not predict nitrate+nitrite and total nitrogen. BMP metrics associated with reductions of instream nutrients included manure storage systems and riparian buffers but not livestock restriction fences. BMPs were able to predict instream nutrients in all seasons; however, BMPs were most associated with nutrients in the summer and spring. Our results suggest that mitigation effects of BMPs do vary intra-annually and additional strategies of BMP use and implementation may be required to protect aquatic ecosystems in the colder seasons. *Keywords: Water quality, Agriculture, Best management practices.*

PEARSALL, D.R.[1], KAHL, K.J.[1], JOHNSON, K.[2], WHELCHEL, A.[3], and ANNIS, G.[1], [1]The Nature Conservancy, 101 E. Grand River Ave, Lansing, MI, 48906, USA; [2]The Nature Conservancy, 1101 West River Parkway, Suite 200, Minneapolis, MN, 55415-1291, USA; [3]The Nature Conservancy, 55 Church St., Floor 3, New Haven, CT, 06510-3029, USA. **Coastal Restoration in Western Lake Erie: Improving Nature and Resilience in Coastal Communities.**

The Western Lake Erie Coastal Conservation Vision (WLECCV) provides the first Great Lakes example of a spatially-explicit conservation plan that advances shared ecological and human well-being goals. Climate resilience is a chief concern for coastal communities, and while the WLECCV can inform conservation for multiple objectives, resilience has not been incorporated. As we pursue coastal restoration with both traditional conservation partners and coastal communities, we anticipate addressing many challenges: 1) defining the role of coastal and nearshore ecosystems in reducing risks and providing benefits to people and nature; 2) identifying socioeconomic values important to specific coastal communities; 3) developing data, analyses and visualizations identified by communities to enable planning discussions about the implications of alternative actions and scenarios for reducing risk and enhancing resilience; and 4) promoting and supporting an adaptive management approach amongst a diverse suite of collaborating partners. Through collaboration with coastal managers, ecosystem service experts, urban planners, marine resilience planning experts, and local communities, we are beginning to address these challenges and expand the WLECCV approach to a broader coastal region. We will describe initial progress and lessons learned. *Keywords: Coastal ecosystems, Coastal resilience, Economic impact, Human well-being, Lake Erie, Planning.*

PEARSON, R.A.[2] and COLE, S.J.[1], [1]Great Lakes Commission, 2805 S Industrial Hwy., Ste. 100, Ann Arbor, MI, 48104, USA; [2]Great Lakes Commission, 2805 S Industrial Hwy., Ste. 100, Ann Arbor, MI, 48104, USA. **Human Use of the Great Lakes Water Resources: What We Know and Don't Know.**

Over the past twenty years, the Great Lakes and St. Lawrence River states and provinces have submitted water use data to a regional repository at the Great Lakes Commission. Water use data includes withdrawals, consumptive uses and diversions by water source, jurisdiction and lake or river watershed. This data collection and management initiative supports the Great Lakes and St. Lawrence River Water Resources Compact and Agreement which establishes a regional framework for water management. Every year, the Great Lakes Commission compiles and summarizes these datasets into an annual report. In 2013, a cumulative impact assessment that compares water loss (e.g., a summation of diversions and consumptive uses) within the context of a water budget for each of the lake and river watersheds was completed, and subsequent interim assessments are now appended to the annual reports. With 24 annual reports published, the Great Lakes Commission continues to assess ways to improve data quality and the collective understanding of water uses in the region with regional partners. This presentation will highlight what we as a region collectively understand about water use and what we do not understand, and outline some research priorities to fill in the knowledge gaps. *Keywords: Management, Withdrawals, Great Lakes basin, Water use data, Water distribution, Water loss.*

PEBBLES, V.[1], SLAWECKI, T.[2], MOLNAR, S.[1], and BRATTON, J.F.[2], [1]The Great Lakes Commission, 2805 S. Industrial Hwy Suite 100, Ann Arbor, MI, 48104, USA; [2]LimnoTech, 501 Avis Drive, Ann Arbor, Mi, 48108, USA. **Identification and Assessment of Information Flows to Improve Great Lakes Water Quality Decisions.**

The International Joint Commission (IJC) is undertaking an effort to identify ecological, human health and program effectiveness indicators to enable documentation of progress towards meeting the objectives of the Great Lakes Water Quality Agreement (GLWQA). Working with the IJC's Information Coordination and Flow (ICF) Work Group, the Great Lakes Commission (GLC) and LimnoTech are working to identify and assess programs and platforms that collect, deliver, and use data and information in the Great Lakes basin to support water quality management and policy decisions. Results from the project's inventory, workshop, metric development, and case study assessments will inform the ICF Work Group and the IJC's Science Priority Committee as they advise the IJC on short- and long-term recommendations for improving data and information flow in the Great Lakes to support GLWQA mplementation. Our presentation will touch on preliminary outcomes, including draft metrics for assessment of information flow quality and early results from their application to case studies on invasive species and beach health. It will also examine on the effectiveness of the project's informatics-based approach in bringing together diverse data and information stakeholders to identify the synergies that will realize better water quality decisions. *Keywords: Data storage and retrieval, Information flow, Decision making, Indicators.*

PENNUTO, C.M.[2] and SLIWINSKI, S.D.[1], [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. **Mottled sculpins exhibit a moderate response to in-stream habitat improvements in Elton Creek (USA).**

Fish community response to stream habitat restoration is generally positive, at least for target species such as trout. However, few projects assess non-target species responses. We assessed the response of mottled sculpins (*Cottus bairdi*) and the remaining fish community before and after a stream restoration effort to improve trout abundance in a stretch of Elton Creek (New York, USA). Single-stone bendway weirs, live stake installations, and large conglomerate rock insertions were used to create velocity cover, stabilize banks and improve temperature regimes for trout. Repeated backpack electroshocking events were completed above and below and before and after the restoration effort. There was no statistical difference between stream reaches when comparing total fish/m^2, sculpins/m^2, total fish/sec, or sculpins/sec. However, sculpins/sec improved following the restoration. In fact, though not statistically significant, all fish community and sculpin metrics improved more in the restoration section after project completion compared to the untreated section. Macroinvertebrate responses to the restoration effort are still under assessment. Results to date indicate a modest response of the non-target fish community to habitat improvements for trout. *Keywords: Fish management, Trout, Tributaries.*

PERLOV, D. and QUINLAN, R., York University, Toronto, ON, CANADA. **Tracking Hypoxia in the Central Basin of Lake Erie Using a Paleolimnological Approach.**

Since European settlement, the Lake Erie ecosystem has experienced major environmental changes, including land-use changes within its catchment, cultural eutrophication in the 1930-1960s, followed by nutrient and pollution abatement programs commencing in the early 1970s, introduction of non-indigenous dreissenids in the 1980s, and re-eutrophication in recent years. The compound effects of climate change and nutrient loading have been particularly influential over recent decades and have serious implications for the lake's trophic status and hypolimnetic oxygen concentrations. Since monitoring data of hypolimnetic oxygen in Lake Erie does not extend beyond recent decades, paleolimnological methods may be used to infer long-term trends in hypolimnetic oxygen conditions and to establish pre-disturbance environmental conditions. This present study examined Chironomidae remains, preserved in a dated sediment core from the central basin of Lake Erie, to assess the cumulative effects of multiple anthropogenic stressors on water

quality over the past ~200 years. Here we present preliminary results. *Keywords: Paleolimnology, Chironomidae, Oxygen, Lake Erie.*

PETCHPRAYOON, P.[1], BLANKEN, P.D.[2], HUSSEIN, K.[3], ABDALATU, W.[3], and LAWAWIROJWONG, S.[1], [1]Geo-Informatics and Space Technology Development Agency, Bangkok, Thailand, USA; [2]Geography Department, University of Colorado-Boulder, Boulder, CO, USA; [3]CIRES, University of Colorado-Boulder, Boulder, CO, USA. **Detecting Changes of Evaporation and Total Water Storage over a Large Lake from Multi-Satellites.**

This study has estimated the spatial and temporal distribution, as well as the long-term changes, in Lake Huron evaporation using remotely-sensed data from MODIS together with field measurements. The evaporation rate was linked to the changes in total water storage and water level by combining the observations of two complementary satellite systems: the gravimetry (GRACE) and altimetry (Jason1/2) satellites. The study found an increase in the evaporation rate approximately of 1.4 mm m^{-2} over the 2005-2013 observation period, the water level decreased by 0.04 m., and there was a decrease in total water storage by 1.18 cm during the entire study period. It was obviously a negative correlation between lake evaporation and lake water level and also total lake water storage. Approximately a two-month delay between the maximum evaporation rate and the time of the lowest water level, whereas total water storage reached the lowest point a half-month earlier than the time of maximum evaporation. These time lags were mainly due to the water level being influent because of the inflow from Lake Superior, while the GRACE total water storage was affected by the signal from the land surrounding the lake. *Keywords: Remote sensing, Water level fluctuations, Spatial distribution.*

PETERSON, L.K. and JONES, M.L., Michigan State University Quantitative Fisheries Center, 153 Giltner Hall, East Lansing, MI, 48824, USA. **Evaluating Methods for Estimating Mortality of Great Lakes Walleye using Acoustic Telemetry.**

Natural mortality is an important dynamic of fish populations and critical component of stock assessment models. However, methods for estimating natural mortality tend to use indirect methods, such as assuming the same mortality rate as a species with similar life history characteristics or assuming a relationship between growth and natural mortality. Acoustic telemetry has the potential to provide a more direct way for estimating mortality. The focus of this project was to develop different estimation approaches and evaluate them using a simulation framework, using the existing Great Lakes walleye acoustic telemetry data as a guide. Two different baseline models, a classic Cormack-Jolly-Seber approach and a spatial capture-recapture approach, as well as variations, were developed to

estimate natural mortality using passive acoustic detections. Simulated data were generated using an individual based modelling approach. Using this simulation framework, different scenarios were evaluated to determine the precision and accuracy of the models under different assumptions of uncertainty. This has the potential to inform researchers about appropriate estimation methods as well as strategies for acoustic telemetry study design for determining natural mortality, such as optimal distribution of receivers or amount of fish tagging effort. *Keywords: Modeling, Walleye, Acoustics.*

PLACH, J.[1], MACRAE, M.L.[1], ALI, G.[2], BRUNKE, R.[3], DUITS, C.[4], ENGLISH, M.[5], LAM, W.V.[1], MCKAGUE, K.[3], O'HALLORAN, I.P.[4], OPOLKO, G.[5], and VAN ESBROECK, C.[1], [1]University of Waterloo, Waterloo, USA; [2]University of Manitoba, Winnipeg, USA; [3]Ontario Ministry of Agriculture, Food and Rural Affairs, Woodstock and London, USA; [4]University of Guelph, Ridgetown Campus, Ridgetown, USA; [5]Wilfrid Laurier University, Waterloo, USA. **Subsurface P Export from Agricultural Lands across Southern Ontario: Transport- or Supply-limited?**

Subsurface phosphorus (P) losses from agricultural lands are a significant environmental and economic concern in the lower Great Lakes region, impacting crop productivity and the degradation of water-quality in downstream aquatic ecosystems. This field-based study evaluates the relative role of hydrologic versus biogeochemical controls on subsurface P losses from agricultural tile drains across Southern Ontario. Water samples were collected at 7 sites over 4 years (2011-2015 inclusive) from fields with varying soil textures (clay to sandy-loam) and a range of P conservation best management practices (BMPs) to characterize the load response of dissolved reactive P (DRP) and total P (TP) from tile drains as transport-limited (system biogeochemical stationary) or supply-limited, and, to evaluate whether P export (event-scale) can be predicted from timing and magnitude of discharge, fertilizer application and precipitation (rainfall and snowmelt). Establishing the chemostatic versus episodic behaviour of P export is fundamental to designing BMPs for reducing P losses during key runoff periods across the region. These results, characterizing subsurface P loadings linked to hydrology and P availability, and their implications for predicting the risk of P movement from agricultural landscapes to surface waters will be presented. *Keywords: Phosphorus, Agriculture, Water quality.*

POINT, A.D., CRIMMINS, B.S., and HOLSEN, T.M., Clarkson University, 8 Clarkson Ave., 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 sample purification method (activated carbon cleanup versus solid phase extraction (SPE)) and sample dispersion technique (contact versus non-contact sonication). LC-MS quantification utilizing the Waters G2-XS Tof mass spectrometer will stress sensitivity in MS^E (full-scan) and Tof-MRM (targeted) 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. Such a procedure is invaluable when paired with the Great Lakes Fish Monitoring and Surveillance Program's tissue archive for gaining insight on temporal contaminant concentration trends. *Keywords: Chemical analysis, Environmental contaminants, Fish.*

PRESCOTT, M.[1], CHUTKO, K.[2], WALTERS, D.[1], JAMES, A.L.[1], PATERSON, A.M.[3], RUSAK, J.A.[3], MCCONNELL, C.J.[3], and YAO, H.[3], [1]Dept. of Geography, Nipissing University, 100 College Drive, North Bay, ON, P1B 8L7, CANADA; [2]Dept. of Geography and Planning, University of Saskatchewan, 117 Science Place, Saskatoon, SK, S7N 5C8, CANADA; [3]Dorset Environmental Science Centre, 1026 Bellwood Acres Road, Dorset, ON, P0A 1E0, CANADA. **A Multi-Year Study of Mixing and Stratification Using Buoy Observations, Lake Nipissing, Ontario.**

Lake Nipissing is a large, shallow mesotrophic lake located on the Canadian Shield in north eastern Ontario. Some of the embayments around Lake Nipissing are reported to be eutrophic, occasionally experiencing harmful algal blooms with potential impacts on recreational activity and local drinking water supply. Starting in 2013, high frequency observations of water (temperature profile, water quality at 1m, dissolved oxygen at 1m below surface and above lake bed) and weather data have been collected in three embayments to understand the physical mechanisms that may contribute to internal phosphorus loading. Analyses of observations collected in 2014 using the Global Lake Ecological Observation Network (GLEON)'s Lake Analyzer package have shown variation in water column dynamics across embayments, with Callander Bay showing multiple periods of thermal stratification and mixing related to wind and rain events. In 2014, conditions observed in Callander Bay suggest potential for internal phosphorus loading by both sediment resuspension and redox reactions, while shallower bays show no evidence of the formation of anoxic conditions. This paper will present a comparison of the 2014 and 2015 high frequency datasets, including a comparison of embayment dynamics in Callander Bay with an open-water location in Lake Nipissing. *Keywords: Buoys, Anaerobic conditions, Sediment resuspension.*

PRESELLO, A.[1], SMITH, J.L.[2], DREW, T.[3], LOFTUS, K.[2], and PITCHER, T.E.[1], [1]Great Lakes Institute for Environmental Research & Biology, University of Windsor, 401 Sunset Ave, Windsor, ON, N9B 3P4, CANADA; [2]Fish Culture Section, Ontario Ministry of Natural Resources and Forestry, 300 Water St., Peterborough, ON, K9J 8M5, CANADA; [3]White Lake Fish Culture Station, Ontario Ministry of Natural Resources and Forestry, 25900 Highway 7, Sharbot Lake, ON, K0H 2P0, CANADA. **Inducing reproduction in bloaters *Coregonus hoyi* to support L. Ontario reintroduction efforts.**

Prior to their extirpation, bloaters (*Coregonus hoyi*) were an important native species of the fish community in Lake Ontario. Recently, there has been a growing effort to restore bloaters to Lake Ontario, including an effort to establish a self-sustaining broodstock capable of producing enough offspring to support reintroduction efforts. One factor that is precluding the creation of a self-sustaining broodstock is the difficulty in matching the environmental cues, associated with the bottom of the lake (where they normally spawn), which are needed to stimulate gamete production and ultimately spawning. As such, this study investigated the efficacy of using luteinizing hormone-releasing hormone analog (LHRHa) to induce gamete maturation and spawning in a fish culture setting. We induced adult bloaters using LHRHa at the Ontario Ministry of Natural Resources and Forestry's White Lake Fish Culture Station. We examined rates of gamete production in four treatments including the (i) high dose treatment, (ii) low dose treatment, (iii) control, and (iv) sham control. We will report on the results of this study and discuss other avenues we are now pursuing in order to create a self-sustaining broodstock capable of producing high quality offspring for restoration efforts. *Keywords: Lake Ontario, Ecosystem health, Conservation.*

PURIC-MLADENOVIC, D. and POND, B., OMNRF, Science and Research Branch, 300 Water Street, Peterborough, ON, K9J 8M5, CANADA. **Assessing natural cover quality in the Lake Simcoe Watershed.**

Areas of natural vegetation in the Lake Simcoe watershed are critical for maintaining ecosystem functions and processes. However, these areas are exposed to many anthropogenic stresses. Land development, invasive species, climate change and habitat fragmentation are among the human pressures that have a significant impact on terrestrial plant communities. It is important not only to assess changes in the area occupied by these communities, but also changes in quality. This is clearly recognized in the Lake Simcoe Protection Plan, which articulates targets of 'greater proportion of natural vegetative cover in large high quality patches' and '40 percent high quality natural vegetative cover', and which proposes 'Change over time in the proportion of land in wetland, forested valleyland, natural riparian and upland forest taking into account habitat quality' as a critical indicator. Identifying objective and sound indicators and thresholds for habitat quality and vegetative

cover quality is challenging, but offers means of monitoring and assessing change over time and space, and will help understand the effects of human disturbance. We collected data following an integrative, multi-purpose, vegetation sampling protocol at over 300 plots in the Lake Simcoe Watershed. From these field data we derived composite measures of function. *Keywords: Monitoring, Natural cover, Vegetation, Lake Simcoe Watershead, Indicators, Quality thresholds.*

Q

QAZAZI, M.S., VASQUEZ, A.A., FAILLA, A.J., RAMA, S., RANDALL, S.J., and RAM, J.L., Wayne State University School of Medicine, 540 E. canfield, Detroit, MI, 48201, USA. **Genetic Diversity of Water Mites in Western Lake Erie.**

Water mites are a highly diverse group of arachnids that are morphologically difficult to analyze and for which many species have yet to be described. A recent study of cytochrome oxidase 1 gene (COI) DNA barcode representation of Great Lakes species reported that water mites are severely underrepresented in publicly available databases (Trebitz et al., 2015). To begin remedying this gap in taxonomic knowledge, this study analyzed water mites collected from Maumee River and Maumee Bay (Western Lake Erie) benthic samples in 2012-2013, identified specimens to genus, and determined their COI barcodes. Limnesia sp. yielded a clade with several branches, some within 1% of previous GenBank sequences and another less than 90% similar. Barcodes of Krendowskia sp. and Koenikea sp. are the first for these genera in GenBank. Subsequent studies of fish stomachs reveal that round gobies eat water mites, including Limnesia sp. and Hygrobates sp.; for which barcode analysis is underway. An interesting question is whether native water mites are contributing to sustaining invasive species like the round goby or whether non-native water mites have become part of Great Lakes food web assemblages. *Keywords: Benthic flora, Microbiological studies, Environmental health.*

QIAN, S.S., The University of Toledo, 2801 West Bancroft Street, Toledo, OH, 43606, USA. **R Implementation of SPARROW.**

The presentation discusses the implementation of the SPARROW model in the open source programming language R, an increasingly popular programming platform for statistical modeling. Because R is freely available and supported by a large user-base, implementation of SPARROW in R can promote a wider user-base. Furthermore, the current SAS implementation of SPARROW is based on the core SAS-macro code written largely in the 1990s. Specifically, the nonlinear regression algorithm used in the current SAS code is based on a linear approximation, rather than the numerical optimization solution of the maximum likelihood estimator. The almost closed nature of the SPARROW program also prevents necessary development of the model to support different needs. The current implementation of SPARROW in R includes two sets of R programs. The first set of programs provides data management functionality for processing the reach-based input data to a format that can be easily used in the R statistical modeling framework. The second set of programs includes a self-starter function for event-free execution of the R nonlinear regression function. The R program and the self-starter function can be easily expanded into a Bayesian hierarchical model, allowing watershed or region specific model coefficients. *Keywords: Modeling, SPARROW, Nutrients, Watersheds.*

R

RAAB, D.[1], MANDRAK, N.E.[2], and RICCIARDI, A.[1], [1]Redpath Museum, Biology Department, McGill University, 859 Sherbrooke St. West, Montreal, QC, H3A 0C4, CANADA; [2]University of Toronto Scarborough, 1265 Military Trail, Toronto, ON, M1C 1A4, CANADA. **Context-dependence of food competition in riverine Round Goby invasions.**

In the Great Lakes, Round Goby is rapidly expanding its range and dominates fish communities in many littoral and benthic habitats. Its ecological impact has been extensively investigated in the Great Lakes proper; however, less is known about its impact in tributaries. We surveyed the Grand River (Ontario) as a model system to assess Round Goby impact on native fishes in a flow-modified tributary. Sequential lowhead dams separate proximate uninvaded and invaded river reaches, and create upstream gradients of increasing water velocity. On invaded reaches, Round Goby abundance exponentially declines with increasing water velocity, whereas native benthic fishes are at their lowest abundance at sites of low water velocity and high goby abundance - a trend not seen on uninvaded reaches. These observations suggest competitive exclusion of native fishes. To assess competition for food as a potential mechanism of exclusion, we examine diet overlap and isotopic niche breadth in Round Goby and two native darters. Niche overlap would indicate impacts are likely to occur when Round Goby establish upstream of lowhead dams. Comparison of niche breadth and trophic position for Round Goby in tributaries with those reported in the Great Lakes proper may also determine if diet specialization is occurring in these newly invaded habitats. *Keywords: Grand River, Credit River, Round goby.*

RABY, M.[1], NOWIERSKI, M.[2], POIRIER, D.G.[3], and SIBLEY, P.[1], [1]University of Guelph, School of Environmental Sciences, Guelph, ON, CANADA; [2]Ontario Ministry of Environment and Climate Change, Standards Development Branch, Toronto, ON, USA; [3]Ontario Ministry of Environment and Climate Change, Laboratory Services Branch, Toronto, ON, CANADA. **Species Sensitivity Distributions for Acute Toxicity of Neonicotinoids to Aquatic Invertebrates.**

Neonicotinoids are a group of agricultural pesticides commonly used in the Great Lakes watershed. They are mainly used in the treatment of corn and soybean seeds to target sucking insect pests. Other uses in Ontario include soil and foliar applications, greenhouses, and tree injections. Neonicotinoids are highly water soluble and can enter receiving bodies of water through run-off and agricultural tile drainage, where they can have detrimental effects on non-target aquatic organisms. While standard toxicity data (e.g. LC50s) exists for some model invertebrates with the most common neonicotinoids (imidacloprid, clothianidin, thiamethoxam), for others (acetamiprid, dinotefuran, thiacloprid) there is relatively little data. Acute lethality tests for six neonicotinoids were conducted with a diverse set of field-collected (>5) and laboratory-cultured (>7) aquatic invertebrate species. Using these data, in conjunction with data obtained from the literature, species sensitivity distributions (SSDs) were plotted, and hazardous concentrations estimated, for each neonicotinoid. This study is in partnership with the Ontario Ministry of Environment and Climate Change, and will help to develop a comprehensive dataset from which to derive water quality criteria for the protection of aquatic life. *Keywords: Neonicotinoids, Toxic substances, SSDs.*

RAKHIMBEKOVA, S., O'CARROLL, D.M., and ROBINSON, C., University of Western Ontario, 1151 Richmond Street, London, ON, N5X 3T9, CANADA. **Fate and transport of septic-derived nutrients to the Great Lakes through a permeable sandy aquifer.**

Nutrient loading to the Great Lakes from septic systems is poorly quantified although they are often cited as an important source of nutrients. Particularly, there is limited understanding of whether nutrients leaching from septic tile beds are in fact delivered to adjacent surface waters. Nutrients may undergo important transformations in the subsurface with their ultimate discharge controlled by a geochemical reaction zone set up near the groundwater-lake interface. The objective of this study is to evaluate the transformation of septic-derived nutrients along their pathway through a sandy homogeneous aquifer from their source (septic tile beds) to nearshore waters. Field investigations were conducted in 2014 and 2015 downgradient of a large public septic system located 140 m from the shores of Lake Huron. Elevated nitrate (NO3-) and phosphate (PO43-) concentrations of 110 mg/L and 450 μg/L, respectively, were observed at depths of 1-3 m at distances 10-40 m landward of the shoreline. Extensive water chemistry data collected over two year period are

analyzed to illustrate the seasonal variability of the discharging nutrient plume. Findings from this field study provide valuable insight on the geochemical controls for septic-derived nutrients discharging to the Great Lakes along the more than 6000 km of permeable shoreline. *Keywords: Water level fluctuations, Septic system, Harmful algal blooms, Groundwater surface water interface, Nutrients, Groundwater discharge.*

RAM, J.L.[1], VASQUEZ, A.A.[1], HUDSON, P.L.[2], FUJIMOTO, M.[1], QAZAZI, M.S.[1], and FAILLA, A.J.[1], [1]Wayne State University, 540 E Canfield St., Dept of Physiology, Detroit, Mi, 48201, USA; [2]Great Lakes Science Center, U.S. Geological Survey, 1451 Green Road, Ann Arbor, MI, 48105, USA. **Digging Deeper into Benthic Biodiversity.**

DNA barcoding using cytochrome oxidase I (COI) sequences reveals heretofore unknown diversity and also an enormous lack of knowledge about many species that even a moderately intensive benthic sampling can discover. Benthic organisms collected on 10 days during 2012/13 from 15+ sites in Toledo Harbor (high risk for invasive species introductions) were identified by EcoAnalysts and COI barcoded by CCDB or the Ram lab. Oligochaetes: stood out as having supposedly identified single species (e.g., *Limnodrilus hoffmeisteri*) represented by large clades with many branches differing by >10% in sequence, indicating numerous potential cryptic species, possibly difficult or impossible to differentiate morphologically. Chironomids: Taxonomic keys to the benthic larval stage often do not extend beyond genus; however, by comparing larval barcodes to barcodes of identified adults (e.g., *Cladopelma viridulum*), Failla et al (2015) identified larval chironomid species. Water mites: had many unique barcodes (e.g., for *Krendowskia* and *Koenikea*), but the problem of identifying species is that up to half of North American water mite species have not yet been named, and most keys only go to genus. These studies have begun to fill in barcode gaps for several understudied diverse groups of benthic invertebrates. *Keywords: Biodiversity, Lake Erie, Benthos.*

REAVIE, E.D.[1], CAI, M.[1], TWISS, M.R.[2], CARRICK, H.J.[3], DAVIS, T.W.[4], JOHENGEN, T.H.[5], GOSSIAUX, D.[4], SMITH, D.E.[6], PALLADINO, D.[5], BURTNER, A.[5], and SGRO, G.V.[7], [1]Natural Resources Research Institute, Duluth, MN, USA; [2]Clarkson University, Potsdam, NY, USA; [3]Central Michigan University, Mount Pleasant, MI, USA; [4]Great Lakes Environmental Research Laboratory, Ann Arbor, MI, USA; [5]Cooperative Institute for Limnology & Ecosystem Research, Ann Arbor, MI, USA; [6]Colorado School of Public Health, Aurora, CO, USA; [7]John Carroll University, University Heights, OH, USA. **Hypoxia in Lake Erie is mostly driven by diatoms.**

Re-eutrophication and harmful algal blooms in Lake Erie have resulted in a renewed call for remedial measures such as reductions of phosphorus loads. Nutrient reductions can

have a remedial effect on hypolimnetic anoxia by reducing algal biomass. However, winter-spring blooms of diatoms have not been fully recognized as a source of algal biomass supporting summer hypoxia. We compared spring and summer phytoplankton abundance in central and western Lake Erie based on monitoring data to show that spring phytoplankton biovolume was 1.5- to 6-fold greater than summer biovolume and that most spring biovolume was composed of filamentous diatoms, primarily *Aulacoseira islandica*, that is likely supported by an increasing silica load from Lake Huron. The rise of silica export was attributed to the dreissenid mussel invasion and establishment that reduced diatom abundance in Lake Huron and thereby increased silica availability in the receiving water body of Lake Erie. Winter-spring diatoms, not summer cyanophytes, are likely contributing the majority of the carbon load to the hypolimnion of the central basin of Lake Erie, so remedial measures aimed at reducing hypoxia in Lake Erie must consider these early-year blooms as important contemporary features of the lake that deliver algal biomass to the profundal zone. *Keywords: Lake Erie, Blooms, Diatoms, Silica, Cyanophyta, Phosphorus.*

REID, D.K., Agriculture and Agri Food Canada, 174 Stone Road W, Guelph, ON, N1G 4S9, CANADA. **Tile Drains as Conduits for P Loss from Agricultural Land - Myths and Reality.**

The agricultural lands in the Great Lakes region, and particularly in the Lake Erie basin, are among the most intensively tile drained in the world. This has led to huge increases in crop yields in this area, but has also increased the hydrological connectivity of farm fields to surface water. While this has undoubtedly had an influence on P transport , the extent and direction of this influence is not clear cut. This presentation will describe the current state of the research regarding the mechanisms in play when P moves from the soil surface to tile drain and will address some common misconceptions as well as implications for P management in the Canadian portion of Great Lakes basin to minimize losses through tile drains. The work described will include recent measurements of partitioning of tile water between matrix and macropore flow to the tiles, and the implications for P transport through tile drains, and the relative amounts of dissolved and particulate P in tile drain outflow. *Keywords: Agriculture, Nutrients, Tile drainage, Phosphorus.*

REID, K.B.[2] and NUDDS, T.D.[1], [1]University of Guelph, Guelph, CANADA; [2]Ontario Commercial Fisheries' Association, Blenheim, CANADA. **Pragmatic governance for Anthropocene fisheries.**

Governance systems intended to achieve sustainable management of fish populations, fishermen and their communities appear slow to adopt the broad interdisciplinarity evident in more recently advocated approaches to fisheries risk assessment and management. We draw upon insights from pragmatism, hermeneutics, Bayesian thinking, operations research and the sociology of organizations to argue that the pragmatic approach is a means for challenging the many barriers to interdisciplinarity and for spanning the science-policy boundary. Pragmatism is a democratic, pluralistic, problem-centered worldview concerned with real-world practice, particularly the consequences of actions. Fisheries governance must be pluralistic, participatory and, critically, broadly interdisciplinary to qualify as pragmatic wherein communities of inquiry test hypotheses. A pragmatic approach would utilize available methodologies, such as Bayesian network models, with their potential to facilitate discourse. While Bayesian and operations research techniques have been shown to be very useful statistical tools for fisheries assessment and management, we show how they also have the capacity to empower boundary spanners, greatly increase the flow of information and ideas across the science-policy boundary, and contribute to a more pragmatic form of governance. *Keywords: Policy making, Pragmatism, Risk assessment, Bayesian, Hermeneutics.*

RENNIE, M.D.[1] and ANDERSON, P.J.[2], [1]Lakehead University, 955 Oliver Road, Thunder Bay, ON, P7B 5E1, CANADA; [2]University of Saskatchewan, 112 Science Place, Saskatoon, SK, S7N 5E2, CANADA. **First Estimate of Microplastic Pollution in Lake Winnipeg.**

Microplastics have been detected across the Great Lakes, even in the headwaters of Lake Superior, despite it's relatively small watershed (128,000 km^2) and sparse population (approximately 600,000) that discharges waste into the lake. By contrast, Lake Winnipeg has a massive watershed (nearly 1,000,000 km^2), and receives wastewater from nearly 7,000,000 people across international borders. We sampled Lake Winnipeg for surface microplastics in 2014 using a standardized sampling apparatus (manta trawl) and survey method, which allows for direct comparison to estimates of surface plastics reported on the Great Lakes. Given it's potential for receiving wastewater from a large area with major population centres, we expected to detect microplastics on Lake Winnipeg in concentrations similar to those observed on the more densely populated Great Lakes. Microplastics were found in all 2014 samples that were examined. Preliminary results show that concentrations were highest at the lake outflow, and were significantly elevated at the northern inflow compared to southern inflows. Results of Scanning Electron Microscopy with Energy Dispersive X-Ray Spectroscopy will be presented to confirm the identity of particle estimates, permitting comparisons with concentrations detected in the Laurentian Great Lakes.
Keywords: Environmental contaminants, Lake Winnipeg, Microplastics.

REZANEZHAD, F., NIEDERKORN, A., PARSONS, C.T., and VAN CAPPELLEN, P., Department of Earth and Environmental Sciences, Ecohydrology Research Group, 200 University Ave West, Waterloo, ON, N2L 3G1, CANADA. **Seasonal biogeochemical processing of nutrients in a groundwater-fed stream.**

The biogeochemical and hydrological processes in the riparian, vadose and hyporheic zones have the potential to significantly influence the fate and transport of nutrients on either side of the surface-groundwater interface. To better understand the temporal and spatial distribution of nutrients within the riparian and hyporheic zones, we conducted a field study on a groundwater-fed stream located in the rare Charitable Research Reserve, Cambridge, Ontario, Canada. Several piezometer nests and a series of passive (diffusion) water samplers, known as peepers, were installed along longitudinal and lateral transects centered on the stream to obtain data on the groundwater chemistry. Samples were analyzed for a suite of inorganic nutrients and other water quality parameters. Groundwater upwelling along the stream resulted in distinctly different groundwater types and associated nitrate concentrations between small distances in the riparian zone (<4m). The results showed that nutrient contaminated groundwater undergoes significant biogeochemical processing during upwelling to the highly reactive interfaces in riparian and hyporheic zones. This site demonstrated the capacity of even small riparian zones to effectively remove nutrients from contaminated groundwater which may prevent eutrophication of receiving water bodies.

Keywords: Biogeochemistry, Groundwater-fed stream, Nutrients.

RICHARDS, A.[1], KIM, D.K.[2], WONG, I.[1], BENOY, G.A.[3], ARHONDITSIS, G.B.[2], and ROBERTSON, D.M.[4], [1]Environment and Climate Change Canada, 867 Lakeshore Road, P.O. Box 5050, Burlington, ON, L7S 1A1, CANADA; [2]University of Toronto, 1265 Military Trail, Toronto, ON, CANADA; [3]International Joint Commission, 234 Laurier Avenue West, 22nd Floor, Ottawa, ON, K1P 6K6, CANADA; [4]USGS, 8505 Research Way, Middleton, WI, 53562, USA. **Evaluating uncertainty in nutrient loading using a Bayesian framework: Bay of Qunite case study.**

The Bay of Quinte, situated on the northeast margin of Lake Ontario (Canada), is an Area of Concern where management has developed specific water quality targets. To examine the spatial patterns in nutrient loading to the Bay, a SPAtially Referenced Regressions on Watershed attributes (SPARROW) model was developed. The SPARROW model was calibrated using a Bayesian calibration framework that accounts explicitly for model uncertainty, such as measurement and prediction errors, as well as, model structure. The calibration and uncertainty analysis was based on 48 stations with monitored loads. To quantify the uncertainty, we examined the effects of removing and adding calibration stations, on the overall model structure. The main advantage of the Bayesian calibration approach is that it can restrict model parameters within ranges based on existing knowledge on the system of interest, thereby improving the model's reliability with more realistic and plausible values. *Keywords: Bay of Quinte, Watersheds, Uncertainty analysis, Nutrients.*

RICHMAN, L.[1], GEORGE, T.[1], and BURNISTON, D.[2], [1]Ontario Ministry of Environment and Climate Change, Etobicoke, ON, CANADA; [2]Environment Canada and Climate Change, Burlington, ON, CANADA. **Dioxin and Furan Contamination in the Whalesback Channel: Legacy of the Pulp and Paper Industry.**

The Spanish Harbour Area of Concern in the North Channel of Lake Huron was contaminated with dioxins and furans (PCDD/Fs) by historical discharges from a pulp and paper mill in the Town of Espanola. Total PCDD/F + dioxin-like PCB concentrations in Whalesback Channel sediment ranged from 1,500-11,000 pg/g (TEQ mean: 86 pg TEQ/g). Concentrations of PCDD/Fs have decreased through time, but there are sport fish consumption restrictions for several species. PCDD/Fs in sediment, mayflies (range:5-10 pg TEQ pg/g) and White Suckers (whole fish:1-23 pg TEQ/g) collected from the Whalesback Channel in 2011 confirmed that PCDD/F were bioavailable from the sediment. This data was used to develop a site-specific benthivorous bioaccumulation model to estimate safe sediment target levels (SSTL) associated with tissue residue guidelines so that fish were considered safe for human consumption. An area average sediment TEQ of < 56 pg/g (TEF Fish) was estimated as the SSTL to reduce PCDD/F exposure in mayflies so that large White Suckers (> 45 cm) feeding on mayflies would have a tissue concentration below the human health consumption limit of 2.7 pg/g. Since sediment contamination is widespread, site specific "hot spot" remedial actions for sediment management will not be practical. *Keywords: Environmental contaminants, Dioxins, Sediments, Food chains.*

RIDDICK, N.L.[1], VOLIK, O.[2], and MCCARTHY, F.M.G.[1], [1]Brock University, 1812 Sir Isaac Brock Way, St. Catharines, ON, L2S 3A1, CANADA; [2]University of Waterloo, 200 University Ave W, Waterloo, ON, N2L 3G1, CANADA. **Wendat (Huron) Impact on Lake Simcoe: Paleolimnological Evidence.**

Land clearing in the Lake Simcoe watershed is recorded by an increase in *Ambrosia* (ragweed pollen), increased siltation and increases in nutrients and heavy metals in sediments. Microfossils in sediment cores from two locations, Smith's Bay and the main basin, record pre-European impact, as well as anthropogenic forcing since the early/mid 19thC. Turbidity negatively affected algae (notably desmids) between the mid- 16thC and mid-17thC and cultural eutrophication caused a change in algal palynomorph assemblages, from olig-mesotrophic to meso-eutrophic taxa. *Helianthus* (sunflower) pollen and the fungus

Ustilago maydis (corn smut), Wendat (Huron) cultivars, was identified in the middle of this zone in the core from Smith's Bay, where siltation is highest. The Wendat lived in large villages and were agriculturalists, therefore significant land clearing was required. Prevailing wind patterns would lead to deposition in the main basin and Smith's Bay from the western coast of the lake, which historically is the eastern border of Wendat territory (Wendake). The mid- 16thC and mid- 17thC age corresponds well with the migration of several Wendat tribes to Wendake and prior to their defeat by the Iroquois. *Keywords: Paleolimnology, Lake Simcoe, Aboriginal, Geoarcheology, Microfossils.*

RIDENOUR, C.H., PARSONS, C.T., and VAN CAPPELLEN, P., Ecohydrology Research Group, University of Waterloo, 200 University Avenue West, Waterloo, On, N2L3G1, CANADA. **Silicon cycling through the Hamilton Harbour Area of Concern.**

In eutrophic environments, silicon (Si) may play an important role in influencing the composition of phytoplankton communities through nutrient limitation. If the growth of diatoms, a siliceous algae, becomes constrained by the availability of Si, the nutrients phosphorus and nitrogen become available in greater supply to fuel potentially harmful (non-siliceous) algal blooms later in the season. An annual mass balance model of nutrient Si through the Hamilton Harbour Area of Concern has been undertaken to determine if the harbour is a net source or sink of nutrient Si. A balanced water budget for the harbour has been developed, and monthly water sampling and analysis for both dissolved and particulate reactive Si is underway. Early results show that wastewater treatment plant effluents, a previously unknown Si source, contribute a considerable flux of potentially bioavailable Si to the harbour (up to 30% of the total Si influx to the harbour). This research will determine if and when stoichiometric Si limitation occurs in Hamilton Harbour and if this could be a causal component for seasonal harmful algal blooms in the area. This research could identify processes to help guide future restoration efforts and contribute to long-term novel nutrient management remediation strategies. *Keywords: Diatoms, Silicon, Hamilton Harbour, Modeling.*

RINCHARD, J., STRATTON, L., and FUTIA, M.H., The College at Brockport - State University of New York, 350 New Campus Drive, Brockport, NY, 14420, USA. **Assessment of Thiamine Deficiency in Lake Trout from Cayuga Lake and Lake Ontario.**

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 thiamine deficiency in lake trout from

Cayuga Lake and Lake Ontario, we monitored thiamine concentration in lake trout eggs from 2009 to 2015. In 2009, the average concentration of lake trout egg thiamine was above the recommended management objective of 4 nmol/g in Cayuga Lake. 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. In Lake Ontario, average concentrations were above the recommended management threshold except in 2012. As observed in Cayuga Lake, large variations in egg thiamine concentration were observed throughout the study. These results indicate that thiamine deficiency is prevalent in both Cayuga Lake and Lake Ontario and is an impediment to lake trout natural reproduction. *Keywords: Lake Ontario, Fish, Lake trout.*

RIOS MENDOZA, L.M.[1], ABEBE, F.[1], DUHAIME, M.B.[2], and CABLE, R.[2], [1]University of Wisconsin Superior, Belknap and Catlin, Superior, WI, 54880, USA; [2]University of Michigan, Ann Arbor, MI, 48109, USA. **Microplastics as a source of Persistent Organic Pollutants in the Laurentian Great Lakes.**

Synthetic microplastic particles are a new type of pollution found in the Laurentian Great Lakes. As part of an integrated research to assess the impact of these microplastics on the health of the Great Lakes ecosystem the adsorption of persistent organic pollutants was quantified. A total of 34 samples collected from summer, 2014 were processed and analyzed by toxic compounds on microplastic particles lower than 5 mm. The FT-IR analysis showed that the main synthetic polymers collected was polypropylene (PP) and polyethylene (PE). The microplastics were classified by color, size, pellets, and fragments. Identification and quantification of PCBs, PAHs and organochlorine pesticides showed wide range of toxic compound concentrations. The overall concentrations (μg/g microplastic) of PAHs were 1.4 to 17 and 0.6 to 10 (ng/g microplastic) for PCBs. *Keywords: Microplastics, PAHs, Toxic substances, PCBs, Environmental contaminants.*

RISENG, C.M.[1], WEHRLY, K.[2], WANG, L.[3], GOODSPEED, R.[1], RUTHERFORD, E.S.[4], MASON, L.[1], and SCHOENFELDT, B.[1], [1]University of Michigan, Ann Arbor, MI, USA; [2]MiDNR - Institute of Fisheries Research, Ann Arobr, MI, USA; [3]International Joint Commission, Windsor, ON, CANADA; [4]NOAA_Great Lakes Science Center, Ann Arbor, MI, USA. **A geospatial framework and spatially referenced decision tools for Great Lakes management.**

The Great Lakes Aquatic Habitat Framework (GLAHF) is a spatial framework and database of physical, chemical and biological data covering the entire Great Lakes basin. These data are georeferenced to a common spatial grid, the framework, which facilitates lake-wide and basin-wide management activities. Great Lakes agencies, managers, and researchers commonly express a need for publicly accessible consistent habitat data and decision support tools that can be applied to the multitude of problems that face aquatic ecosystems throughout the basin. The GLAHF project team has developed a number of web-accessible tools to assist with habitat monitoring, assessment, and prioritization for protection and restoration including: a scalable habitat classification framework; a GIS data viewer and server; and, a web-based decision support system to facilitate research and management activities in the Great Lakes. These spatially structured tools have been developed based on feedback from managers and experts directly involved with making management decisions in the basin and address their specific information needs. GLAHF and theses decision tools could be used to develop lake-wide management plans, prioritize locations for funding and specific management actions, and to conduct research for science-based decision making. *Keywords: GIS, Decision making, Lake management.*

RITCHIE, S.D.[1], MANDRAK, N.E.[1], LENTINI, A.[2], and PHILLIPS, J.[2], [1]University of Toronto Scarborough, 1265 Military Trail, Toronto, ON, M1C 1A4, CANADA; [2]Toronto Zoo (Adopt-A-Pond Wetland Conservation Programme), 361A Old Finch Avenue, Toronto, ON, M1B 5K7, CANADA. **Overwintering Success of Headstarted Blanding's Turtles in a Restored Wetland Complex.**

The Blanding's turtle (*Emydoidea blandingii*), a Threatened species in Ontario, is expected to become extirpated in urban environments without mitigation.Toronto Zoo's Adopt-A-Pond Wetland Conservation Programme has been working with partners to restore critical turtle habitats in Rouge National Urban Park (RNUP) while supplementing the existing Blanding's turtle population with two-year old headstarts. RNUP has a variety of tributaries, including the Rouge River, that act as movement corridors for turtles. However, a lack of suitable wetland habitat adjacent to or near these tributaries limits the dispersal of existing urban populations. Environmental variables directly influence the survival of overwintering turtles. The selection and availability of appropriate overwintering sites can minimize threats, such as acidosis and tissue freezing. This research project will examine the location of successful overwintering sites used by headstart Blanding's turtles in a man-made wetland complex, as well as the relationship between site selection, survival and environmental conditions such as temperature, dissolved oxygen content, vegetation, substrate, and water depth. The results of this research will provide important insight for future wetland restoration design and population supplementation programs around the Great Lakes. *Keywords: Urban watersheds, Blanding's Turtles, Overwintering Success.*

ROBERTSON, D.M.[1], SAAD, D.A.[1], BENOY, G.A.[2], JENKINSON, R.W.[2], VOUK, I.[3], BURCHER, R.S.[3], and JOHNSTON, C.M.[4], [1]U.S. Geological Survery, Wisconsin Water Science Center, 8505 Research Way, Middleton, WI, 53562, USA; [2]International Joint Commission, Canadian Section, 234 Laurier Ave. West, Ottawa, ON, K1P6K6, CANADA; [3]National Research Council of Canada, 1200 Montreal Road, Ottawa, ON, K1A0R6, CANADA; [4]U.S. Geological Survey, NH/VT Water Science Center, 331 Commerce Way, Pembroke, NH, 03275, USA. **SPARROW Watershed Modeling of the Entire Great Lakes Basin.**

Eutrophication problems in the Great Lakes and its tributaries are being addressed as part of a binational effort developing SPARROW (SPAtially Referenced Regression On Watershed attributes) models that simulate phosphorus (P) and nitrogen (N) loading in streams throughout the mid-continental region of North America. These models are using smaller catchments than used in previous SPARROW models (~1 km2 catchments) to enable improved spatial descriptions of where and from what sources the P and N originate. The models are being calibrated using P and N loads from sites monitored by U.S. and Canadian organizations, including data from smaller watersheds than used in previous models. Binationally harmonized geospatial datasets have been developed to describe the streamflow network, nutrient sources (location and quantity), and the environmental characteristics affecting nutrient delivery from the modeled catchments. Model results are being used to: 1) estimate the total P and N input to each Great Lake; 2) rank all of the tributaries to each lake based on their loads and yields; and 3) estimate the relative importance of each of the known nutrient sources, including contributions from upstream lakes not included in previous SPARROW models. *Keywords: Watersheds, Nutrients, Model studies.*

ROBICHAUD, C.D. and ROONEY, R.C., University of Waterloo, 200 University Ave. West, Waterloo, ON, N2L 3G1, CANADA. **Field plots in Phrag: Revealing mechanisms of *Phragmites* success.**

Non-native *Phragmites australis* is one of the most aggressive wetland invaders in North America, able to convert diverse wetland plant communities into dense, monotypic stands in just a few years. Producing stands that can reach up to 14 feet in height, *Phragmites* is taller than most wetland plants and can capture more light while shading out neighbours. *Phragmites* is capable of displacing resident species, but the relative importance of the competitive mechanisms it uses are unknown, hampering risk assessment and restoration success. We hypothesized that resident species *Carex* spp., *Calamagrostis* spp., and *Typha* spp. in above ground competition with *Phragmites* will be less productive than those growing without *Phragmites'* influence, even when below ground interactions are physically restricted.

We tested this with a field plot experiment to determine the intensity of above ground competition for light using a relative competition index (RCI). We found that light penetration and soil conditions were influenced by *Phragmites* invasion, and that above ground competition with *Phragmites* yields detectable effects on resident species productivity. *Keywords: Lake Erie, Invasive species, Wetlands.*

ROBSON, M.[1], JOBST, K.[2], SHEN, L.[2], PENA, M.[2], HELM, P.[2], REINER, E.[2], JENKINS, S.[2], MACINNIS, G.[3], MARVIN, C.[3], BRINDLE, I.[1], and MACPHERSON, K.[2], [1]Brock University, St. Catharines, ON, CANADA; [2]Ontario Ministry of the Environment and Climate Change, Toronto, ON, CANADA; [3]Environment Canada, Burlington, ON, CANADA. **Halogenated Organic Contaminants in Passive Samplers from Lake Ontario Waters and Wastewaters.**

Passive samplers are convenient tools for targeted monitoring and non-targeted screening for potentially hydrophobic organic contaminants to which organisms may be exposed in aquatic environments. Polyethylene (PE) passive samplers were deployed in nearshore areas of western Lake Ontario adjacent to urban landscapes, and in effluents of wastewater treatment plants discharging to Lake Ontario. The PE were analyzed for a broad suite of halogenated flame retardants (HFRs) by gas chromatography-high resolution mass spectrometry and liquid chromatography-tandem mass spectrometry. In lake waters, polybrominated diphenylethers were the most abundant HFR with dissolved phase concentrations ranging 9-34 pg/L, and up to 500 pg/L in a sample strongly influenced by wastewater. Hexabromocyclododecane was the next most abundant brominated compound (0.3-5.8 pg/L), while other replacement HFRs were at sub pg/L concentrations if detected. Non-targeted analyses may help identify other bioavailable compounds such as transformation not currently included in targeted analyses. High resolution time-of-flight mass spectrometry of PE extracts and organization of results by Kendrick plots indicated the presence of compounds related to triclosan and halogenated anisoles. Results from passive samplers can guide contaminant analyses in other matrices. *Keywords: Lake Ontario, Flame retardants, PBDEs, Passive sampling, Mass spectrometry.*

ROESCH, R., LAZBW, fisheries research station, Argenweg 50/1, Langenargen, 88085, GERMANY. **Lake Constance fish and fisheries: intensively influenced by re-oligotrophication and stickleback.**

Lake Constance is situated between Switzerland, Austria and Germany. With a surface area of 536 km² it is the third largest lake in Middle Europe. It consists of the larger Upper Lake (ULC) and the smaller Lower Lake. In the following only ULC is considered. ULC has a surface area of 473 km² and a maximum depth of 254 m. It has undergone intensive re-oligotrophication in recent years. A statistics of the professional fisheries yield exists since 1910. Since middle of the 1990's professional fisheries yield decreased drastically. In 2015 fisheries yield decreased by further about 50% compared to 2014. This decrease is not to be explained by re-oligotrophication but by a massive invasion of the pelagic zone of the lake with stickleback (Gasterosteus aculeatus), which was detected first in autumn 2014. Stickleback actually comprise more than 60% of the fish population in the pelagic zone. Stickleback is not native to Lake Constance. Whitefish (Coregonus lavaretus) reacted drastically to stickleback invasion by further growth retardation, lower whole body energy content and lower GSI. Furthermore it is assumed that recruitment of whitefish and perch (Perca fluviatilis) is negatively influenced by stickleback predation. *Keywords: Invasive species, Fish populations, Stickleback, Fisheries, Nutrients.*

ROSAMOND, M.S.[1], SCHIFF, S.L.[1], MOHAMED, M.N.[2], and TAYLOR, W.D.[1], [1]University of Waterloo, 200 Univeristy Ave W., Waterloo, ON, N2L 3G1, CANADA; [2]Ontario Ministry of the Environment and Climate Change, 125 Resources Rd, Toronto, ON, M9P 3V6, CANADA. **SRP:TP in Rivers and Streams in the Great Lakes Basin: Range and Relevance.**

Harmful algal blooms (HABs) and nearshore algal fouling have increased in Lake Erie since the 1990s, although total phosphorus (TP) loading targets have been reached. Several factors may be responsible, including changes to internal P loading and transport and increased soluble reactive phosphorus (SRP) loading. However, the bi-national Lake Erie Join Action Plan aims for a 40% reduction in TP (not SRP) loading. This implies support for agricultural best management practices (BMPs) targeting TP, which are, in some cases, very different from those targeting SRP specifically. Additionally, SRP:TP in Ontario's tributaries is poorly characterized, but seems to be lower than in Ohio. We present SRP and TP measurements from 15 small, agricultural watersheds in Ontario, and from the Grand River, a 300-km river in a mixed-use watershed. While SRP:TP can be very high in small, agricultural watersheds, SRP:TP typically declines downstream in the Grand River, unless impacted by point sources (e.g. wastewater outfalls and reservoirs). We also examine seasonal and temporal trends in SRP:TP and its predictability with land use. Understanding SRP and TP inputs to the Great Lakes will help our understanding of controls on re-eutrophication and inform agricultural BMP selection. *Keywords: Phosphorus, Water quality, Watersheds.*

ROSAMOND, M.S.[1], MOHAMED, M.N.[2], and TAYLOR, W.D.[1], [1]University of Waterloo, 200 Univeristy Ave W., Waterloo, ON, N2L 3G1, CANADA; [2]Ontario Ministry of the

Environment and Climate Change, 125 Resources Rd, Toronto, ON, M9P 3V6, CANADA. **Has Total Phosphorus Export from Small, Agricultural Streams in Ontario Changed Since the 1970s?**

The re-eutrophication and emergence of harmful algal blooms in Lake Erie has spurred a bi-national agreement to a 40% reduction in total phosphorus (TP) loading to the lake, focusing on non-point agricultural loadings. Intensive, regional-scale analyses of TP export in small, agricultural watersheds in southern Ontario were last performed in the 1970s, under the Pollution from Land Use Activities Research Group (PLUARG) project. Since then, both agricultural practices and climate have changed. While our understanding of P cycling in watersheds continues to improve, large questions remain. We compare modern (2006-2009) seasonal patterns in and landscape controls on TP export from 15 small, agricultural catchments in southern Ontario to those found in the 1970s. Though direct comparisons are scarce, TP export seems to have stabilized or increased over the last 40 years, although overall P inputs to Lake Erie have decreased. A larger fraction of discharge and export now occurs in winter, likely due changes in climate. PLUARG found that TP export was well-predicted with row crops and soil texture; we find a similarly strong relationship with fertilizer P requirement and annual runoff. These results may help guide future research and management strategies for non-point P pollution to the Great Lakes.
Keywords: Phosphorus, Water quality, Watersheds.

ROSS, J.A.[1], HERBERT, M.E.[1], SOWA, S.P.[1], CHRISTOPHER, S.F.[2], TANK, J.L.[2], ARNOLD, J.G.[3], WHITE, M.J.[3], HAW, Y.[4], FRANKENBERGER, J.R.[5], and KING, K.W.[6], [1]The Nature Conservancy, 101 E. Grand River, Lansing, MI, 48906, USA; [2]University of Notre Dame, Department of Biological Sciences, 192 Galvin Life Science Center, Notre Dame, IN, 46556, USA; [3]USDA-ARS, Grassland Soil and Water Research Laboratory, 808 East Blackland Rd., Temple, TX, 76502, USA; [4]Texas A&M University, Blackland Research & Extension Center, 720 East Blackland Rd., Temple, TX, 76502, USA; [5]Purdue University, Department of Agricultural and Biological Engineering, 225 S. University St., West Lafayette, IN, 47907, USA; [6]USDA-ARS, Soil Drainage Research Unit, 509 Woody Hayes Dr., Columbus, OH, 43210, USA. **Watershed-scale modelling of drainage practices to improve water quality in Western Lake Erie.**

Much of the Western Lake Erie Basin (WLEB) relies upon tile drainage and channelization to make lands more suitable for agricultural production. Artificial drainage improves crop production and reduces surface runoff and sediment loss, but also alters hydrology and increases nutrient transport to surface waters. Nutrient loading into streams degrades water quality leading to eutrophication of receiving waterbodies. This promotes harmful algal blooms and hypoxic and anoxic conditions commonly observed in WLE. Studies have shown that two conservation practices, drainage water management and 2-stage ditch, can reduce nutrient loading from artificial drainage. We developed models to predict changes in nutrient loads and concentrations of receiving waters and incorporated these models into the Soil and Water Assessment Tool (SWAT). We used new SWAT algorithms to model nitrate and dissolved reactive phosphorus reductions for streams throughout the WLEB, and mapped results separately for each practice. We also evaluated predicted combined benefit of the practices. These new capabilities provide resource managers with the ability to assess potential benefits of these practices at watershed scales. This presentation covers development of these two models, their incorporation into SWAT, and results of applying these models to WLEB. *Keywords: Nutrients, Conservation Practices, Eutrophication, Lake Erie.*

ROWE, M.D.[1], ANDERSON, E.J.[2], VANDERPLOEG, H.A.[2], YOUSEF, F.[3], LESHKEVICH, G.[2], and SAYERS, M.[4], [1]University of Michigan CILER, 4840 S State Rd, Ann Arbor, Mi, 48108, USA; [2]NOAA GLERL, 4840 S State Rd, Ann Arbor, Mi, 48108, USA; [3]Michigan Technological University, 1400 Townsend Dr, Houghton, MI, 49931, USA; [4]Michigan Tech Research Institute, 3600 Green Ct., Ann Arbor, MI, 48105, USA. **Post-dreissenid spatial distribution of chlorophyll in a Lake Michigan biophysical model.**

Spring phosphorus concentration in Lake Michigan declined over the period of the quagga mussel (*Dreissena rostriformis bugensis*) invasion, making it difficult to discern the relative influence of quagga mussel filter feeding versus declining phosphorus concentration on chlorophyll distribution from analysis of observational data alone. We applied the 3-D, unstructured-grid, Finite-Volume Community Ocean Model (FVCOM) - General Ecological Model (GEM), including tributary phosphorus loads and a dreissenid bioenergetic model. Simulations were initialized with quagga mussel biomass spatial distribution based on NOAA GLERL's lakewide benthic surveys for 2000, 2005, and 2010. We compared modeled to satellite-derived and in-situ measured chlorophyll patterns, with and without simulation of quagga mussel filter feeding and nutrient loads. Winter stratification in March limited vertical mixing, promoting phytoplankton growth while reducing mussel grazing. Tributary phosphorus loads supported nearshore productivity even when offshore productivity was reduced by filter feeding. In the summer stratified period, direct reduction of chlorophyll by filter feeding was minimal, and large-scale upwelling/downwelling dynamics had a strong influence on transport of chlorophyll-rich plumes from river-derived nutrients. *Keywords: Lake Michigan, Dreissena, Model studies.*

RUBERG, S.A.[1], LESHKEVICH, G.[1], STUART, D.J.[2], SAYERS, M.[3], SHUCHMAN, R.A.[3], and GRIMM, A.G.[3], [1]NOAA-GLERL, 4840 S. State Rd., Ann Arbor, MI, 48105, USA;

[2]Cooperative Institute for Limnology and Ecosystems Research, G110 Dana Building, 440 Church Street, Ann Arbor, MI, 48109, USA; [3]Michigan Tech Research Institute, 3600 Green Ct., Ann Arbor, MI, 48105, USA. **Inherent and Apparent Optical Property Observations and Trends in Western Lake Erie for 2015.**

Weekly measurements of inherent and apparent optical properties (IOP/AOP) were made by NOAA/GLERL and MTRI at sites in western Lake Erie from May through October in 2015. 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 (AOPs). 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 IOP/AOPs primarily due to prolific blooms of harmful cyanobacteria (cyanoHABs) in Lake Erie. Significant differences in absorption spectra were observed spatially and temporally throughout the observation period. 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. The IOP/AOP measurements were used to evaluate current remote sensing water quality algorithms. *Keywords: Remote sensing, Lake Erie, Harmful algal blooms.*

RUBERG, S.A.[1], MUZZI, R.W.[1], VANDER WOUDE, A.J.[2], LESHKEVICH, G.[1], JOHENGEN, T.H.[2], MILLER, R.J.[2], MASON, D.M.[1], and DONAHUE, D.[1], [1]NOAA / Great Lakes Environmental Research Lab, 4840 S. State Rd, Ann Arbor, Mi, 48108, USA; [2]Cooperative Institute for Limnology and Ecosystems Research, 4840 S. State Rd, Ann Arbor, Mi, 48108, USA. **Observing Systems Technology Development at NOAA/GLERL.**

The Great Lakes Environmental Research Laboratory has developed an observing system network that includes real-time information collected from buoys and research vessels and remote sensing from satellites and aircraft. The buoy network utilizes network technology to provide high bandwidth information such as underwater imagery and fisheries acoustics data along with standard physical and chemical observations. Remote sensing projects collect information on the extent of mussel coverage using acoustic imaging and airborne systems provide detection mapping, and classification of harmful algal blooms. Nutrient measurement systems have been deployed to permit distinction between river and

wind-driven resuspension events. Underway data collection systems provide transect data collection on research vessels. *Keywords: Buoys, Observing systems, Remote sensing.*

RUCINSKI, D.K., VERHAMME, E.M., DEPINTO, J.V., REDDER, T.M., and SCHLEA, D.A., LimnoTech, 501 Avis Dr., Ann Arbor, MI, 48104, USA. **Modeling Ecosystem Responses to Nutrient Load Reductions using the Saginaw Bay Ecosystem Model.**

A three dimensional coupled hydrodynamic-ecosystem model that was previously developed for Saginaw Bay has been refined spatially, and re-calibrated for 2009-2010 in-lake data. The model includes nutrient dynamics, lower food web interactions, dreissenid growth and impacts on nutrient cycling and light regime, and benthic algal (Cladophora) growth, sloughing, and fate of sloughed material. The development of this third generation of the model, called SAGEM3, is presented, along with simulated ecosystem responses based on hypothetical nutrient load reductions in the watershed. Additionally, an analysis of the potential impact of load reduction strategies in various parts of the watershed is discussed. *Keywords: Modeling, Cladophora, Nutrients.*

RUDSTAM, L.G.[1], CURRIE, W.J.S.[2], JOHNSON, T.[3], WEIDEL, B.C.[4], BOWEN, K.L.[2], WATKINS, J.M.[1], COLLIS, L.M.[1], CONNOLLY, J.K.[1], PAUFVE, M.R.[1], and HOLECK, K.T.[1], [1]Cornell University, 900 Shackelton Point Road, Bridgeport, NY, 13030, USA; [2]Department of Fisheries and Oceans Canada, Burlington, ON, CANADA; [3]Ontario Ministry of Natural Resources and Forestry, Glenora, ON, CANADA; [4]USGS-Great Lakes Laboratory, Oswego, NY, USA. **Zooplankton Community Regulation in Lake Ontario: Inferences from Spatial Distributions.**

Zooplankton abundance and biomass were measured across Lake Ontario during the CSMI year of 2013 by several agencies around the Great Lakes (NYSDEC, OMNRF, USGS, DFO, and EPA). This data was collated at Cornell University into a coherent database available to all participants. Here we use the observed spatial distribution across the lake and across seasons to investigate hypotheses for the regulation of zooplankton species composition in the lake. We also compare the 2013 data with trends through time. Community structure in 2013 was returning to the structure observed in the late 1990s early 2000s with a dominance of cyclopoid copepods and cladocerans. This coincide with a decline in the predatory invasive spiny water flea, *Bythotrephes*, in 2013. Such correlations support the hypothesis that the species composition is regulated by *Bythotrephes* predation. However, spatial distribution showed the same changes in species composition occurring across the lake regardless of the spatial patterns in *Bythotrephes* abundance. We discuss these inconsistencies in the spatial and temporal data in light of other possible explanations that

could be consistent with both patterns, such as nutrients, primary production, light regimes, and alewife abundance. *Keywords: Zooplankton, Spatial distribution, Lake Ontario.*

RUTLEDGE, J.M. and CHOW-FRASER, P., McMaster University, 1280 Main St. W., Hamilton, ON, L8S 4K1, CANADA. **Landscape Characteristics Driving Spatial Variation in Nutrient Loading to the Nottawasaga River.**

Eutrophication from agricultural runoff is a global problem, often resulting in formation of anoxic zones. The Nottawasaga River Watershed (NRW) drains 2,900 km2 of predominantly agricultural land into Nottawasaga Bay, Georgian Bay. A fundamental feature of the NRW is the Minesing Wetlands, a Ramsar site and the largest inland wetland in southern Ontario. We determined daily summer baseflow loading rates (TP, TSS) from 11 main subwatersheds. Existing nutrient export models produced overestimated and inconsistent loading rates across subwatersheds, and did not offer a way to account for the unique hydrological properties of the Minesing Wetlands. Our study reveals that landscape characteristics (slope, soil, watershed size) drive land cover distribution and loading rates within the NRW. Moderate slopes were associated with pasture, forest, and barren land cover classes whereas gentle slopes were associated with crop and wetland. We also found that pasture was the land cover class driving high TP and TSS loading rates in NRW. Internal P loading induced by anoxic conditions within the Minesing Wetlands may be the reason for disproportionately high TP loads in affected subwatersheds. This study offers a new approach to predict TP and TSS loading rates during the growing season using readily available geospatial data. *Keywords: Tributaries, Phosphorus, Watersheds.*

S

SAAD, D.A.[1], ROBERTSON, D.M.[1], and BENOY, G.A.[2], [1]U.S. Geological Survey, Wisconsin Water Science Center, 8505 Research Way, Middleton, WI, 53562, USA; [2]International Joint Commission, Canadian Section, 234 Laurier Avenue, Ottawa, ON, K1P 6K6, CANADA. **Load Estimation Methods for Binational Midcontinental Nutrient SPARROW Models.**

Binational nutrient SPARROW (SPAtially-Referenced Regressions On Watershed attributes) models are being developed for the Midcontinental area of North America (including the Great Lakes, Upper Mississippi, Ohio, Winnipeg and Red-Assiniboine Watersheds) to describe the sources and transport of nutrients from streams and rivers to downstream receiving waters, including the Great Lakes and Lake Winnipeg. The models are calibrated against observed loads estimated from measured nutrient concentrations and stream discharge. Across the Midcontinental area, many stream sites are sampled for nutrients and streamflow; however, sites are required to meet certain criteria (number of samples, length of record, proximity of data to base year, etc.) before they are used for load estimation. Nutrient loads are being estimated using regression, weighted regression, and ratio estimator techniques. Final loads, used as calibration targets in the SPARROW models, will be selected from the regression or weighted regression methods, but only after passing bias and error evaluation, plus an evaluation of bias relative to the ratio estimator method. In the Midcontinental area, nutrient loads will be estimated at several thousand stream sites; however, once calibrated, the SPARROW models will estimate nutrient loads at over a million stream locations. *Keywords: Nutrients, Load estimation, Great Lakes basin.*

SAATI, R. and FULTHORPE, R.R., University of Toronto, 1065 Military Trail, Toronto, ON, M1C1A4, CANADA. **Molecular Profiling of Harmful Algal Blooms in Hamilton Harbour, Lake Ontario.**

Hamilton Harbour is a highly impacted region of Lake Ontario that has been devastated by pollution and nutrient overloads. Despite reduction in phosphorus loads in the 1970's, Harmful Algal Blooms (HABs) have recurred since the 1990's and therefore other factors are at play. We used molecular fingerprinting, amplicon and shotgun sequencing to investigate the microbial community structure within the Hamilton Harbour epilimnion throughout the 2014 and 2015 HAB seasons. Tag-encoded pyrosequencing of eukaryotic small subunit ribosomal RNA (SSU rRNA) genera revealed a diversity of Metazoa, Chlorophyta, and SAR group including a novel Rhizaria. Prokaryotic SSU rRNA showed the predominance of Actinobacteria, Proteobacteria and Cyanobacteria. The Actinobacteria:Cyanobacteria ratio decreased throughout the summer with microcystin producers peaking in August/September. Overall there was significant year-to-year variability in the diversity and abundance of Cyanobacteria. We amplified *nifH* genes and detected at least 3 main taxa capable of N-fixation in the communities of both summers. The metagenome of 2015 communities has also been obtained. We discuss the functional capabilities within the context of our understanding of bloom community structures and their responses to key physicochemical parameters throughout HAB season.
Keywords: Microbiological studies, Harmful algal blooms, Hamilton Harbour.

SALMASO, N., CERASINO, L., BOSCAINI, A., and CAPELLI, C., Fondazione E. Mach, Istituto Agrario di S. Michele all'Adige, Via E. Mach 1, S. Michele all'Adige (Trento), 38010, ITALY. **Expansion of New Cyanobacteria to the Large Italian Lakes: Ecological and Management Implications.**

Since the 1990s, the large lakes south of the Alps (Garda, Iseo, Como and Maggiore) were colonised by *Dolichospermum lemmermannii*. The development of this cyanobacterium was followed, in 2014, by the discovery of *Tychonema bourrellyi*. While the impact of *Dolichospermum* was limited to the development of surface "oligotrophic" water blooms during the summer months, a very recent investigation carried out in Lake Garda showed that *Tychonema* developed with biomasses comparable or higher than those of *Planktothrix rubescens*. Until now, *Planktothrix* was considered the dominant cyanobacterium in the southern perialpine lake district, and the principal producer of microcystins (MCs). Conversely, many isolates of *Tychonema* tested positive for the presence of the genes encoding anatoxin-a (ATX), and for the production of ATX. The increasing importance of *Tychonema* in Lake Garda could be confirmed by the increasing trend of ATX observed since 2009, which was followed by a concurrent decreasing trend of MCs. These changes are strongly altering the cyanobacterial community and the associated cyanotoxin profile of the large Italian lakes. The causes will be discussed considering in detail the analysis of the long-term data recorded in Lake Garda. *Keywords: Cyanophyta, Lake Garda, Harmful algal blooms, Perialpine lakes, Invasive species.*

SALONI, S., University of Western Ontario, London, ON, CANADA. **Evaluating Hydrologic Connectivity in the Prairie Potholes of Southern Alberta.**

The majority of wetland loss occurs due to a poor understanding of their role in maintaining a continuum of hydrologic connectivity in landscapes, which can have immense implications for the provision of ecological functions and ecosystem services to the society. Hydrologic connectivity is defined by the presence of surface and sub-surface flowpaths that are extensive networks connecting landscape within and across watershed boundaries. We will use novel remote sensing and digital terrain analysis to capture the spatio-temporal variability of the hydrological network in the Nose Creek watershed, a part of the Prairie Pothole Region in southern Alberta, which drains into Lake Winnipeg- 2013's most threatened lake of the year. This network comprising wetlands and lakes as nodes and streams as links will be analyzed using circuit theory which measures connectivity between nodes by the amount of current flowing through multiple pathways of varying resistance. Scenario modeling proposed (i) random loss of wetlands; (ii) loss of wetlands with minimum area will help to evaluate the importance of individual wetlands in maintaining hydrologic connectivity in the region. The anticipated results will provide a strong decision-making tool for effective wetland conservation and management. *Keywords: Wetlands, Hydrology, Connectivity.*

SAMARASIN, P.[2], REID, S.M.[1], and MANDRAK, N.E.[2], [1]Ontario Ministry of Natural Resources and Forestry, 1600 West Bank Drive, Peterborough, ON, K9L 0G2, CANADA; [2]University of Toronto at Scarborough, 1265 Military Trail, Toronto, ON, M1C 1A4, CANADA. **Species richness and sampling for detection of fish species-at-risk in Ontario wetlands.**

One third of Ontario fish species-at-risk (SAR) are found in Great Lakes and nearby coastal wetlands. Typically, analyses of fish survey data do not account for imperfect detection, which can lead to erroneous inferences about species richness, occupancy, and population trends in individual species. In addition, understanding sampling effort required to detect and monitor fish SAR is important for making robust inferences on species richness and occupancy, ultimately leading to improved management of SAR. We estimated species richness in seven Ontario wetlands using classical species richness estimators that do not explicitly incorporate imperfect detection and a Bayesian hierarchical model that incorporates imperfect detection. We also evaluated the effect of conducting surveys with (i.e., closed sampling unit) and without (i.e., open sampling unit) a block-net on species richness estimates and composition. Our results suggest that adding sampling sites increases species counts better than conducting additional surveys at the same site. However, at least three repeat surveys at most sites are required to detect more than 80% of the species at the site. Our comparison of species compositions measured using open and closed sampling designs did not indicate substantial differences.

SARAZEN, J.C.[1], KINSMAN-COSTELLO, L.E.[2], JEFFERSON, A.J.[3], and SCHOLL, A.[4], [1]Oberlin College Department of Biology, Oberlin, OH, 44074, USA; [2]Kent State University Department of Biological Sciences, Kent, OH, 44240, USA; [3]Kent State University Department of Geology, Kent, OH, 44240, USA; [4]Kent State University Department of Geography, Kent, OH, 44240, USA. **The effect of antecedent soil moisture conditions on green roof runoff water quality and quantity.**

One of the many benefits of green roofs is that they reduce the amount of stormwater runoff as compared to normal roofs, however they can negatively impact water quality. This study was conducted at the three year-old green roof on Cleveland Metropark's Watershed Stewardship Center in Parma, Ohio. The objectives were to (1) measure green roof runoff quantity and quality of phosphate (PO_4^{3-}), nitrate (NO3-) and ammonium (NH4+) concentrations during rain events and (2) relate antecedent soil moisture conditions to water quality and quantity. We sampled sequential water samples (Teledyne, ISCO) during four summer 2015 rain events that varied in size and intensity. We measured soil moisture at high temporal resolution using four logging sensors and two to three times per week at 33 sampling locations using a handheld probe. Soil moisture increased immediately upon

commencement of rainfall. Spatial data show a response in the soil to rain events with high variability, but no clear patterns. Phosphate export increased linearly with total outflow, while ammonium and nitrate export did not show clear relationships with outflow quantity. Results of our study show that there is a trade off between ecohydrologic function and water quality, as indicated by leaching of excess nutrients in the green roof outflow.
Keywords: Water quality, Green Roof, Urban watersheds, Green Infrastructure, Lake Erie.

SAWTELL, R.[1], SULLIVAN, G.[1], SAYERS, M.[1], LEKKI, J.[2], ANDERSON, B.[2], LIOU, L.[2], and SHUCHMAN, R.A.[1], [1]Michigan Tech Research Institute, 3600 Green Ct., Ann Arbor, MI, 48105, USA; [2]NASA Glenn Research CEnter, 21000 Brookpark Rd., Cleveland, OH, 44135, USA. **Next day generation of water quality products to support NASA Hyperspectral Imaging of Lake Erie.**

n 2015 NASA Glenn operated a hyperspectral imaging system (HSI) from a small aircraft in an effort to provide information regarding harmful cyanobacteria (cyanoHAB) presence in Lake Erie and the Ohio River. The team flew missions at least once a week in Lake Erie from July-October covering areas where in situ measurements were routinely collected as well as many water intake locations. To facilitate the prompt dissemination of cyanoHAB occurrence information to vested stakeholders, near real-time (next day) processing was performed. An automated process was developed which atmospherically corrected all images using an empirical flat field approach. Two cyanoHAB detection algorithms, including the cyanobacterial index (CI) and surface scum index (SSI) were then applied to the images to generate occurrence maps. There was good agreement between HSI derived CI and SSI images and coincident in situ data indicating the HSI is producing accurate data. The high spatial resolution of the HSI provided unique information which is not always available through current satellite observations. Small scale features were detected near the Toledo intake at the beginning of the bloom that were not visible from space. The HSI is also able to fly under complete cloud cover producing results while the lake was unobservable from space. *Keywords: Remote sensing, Lake Erie, Harmful algal blooms.*

SAYERS, M., FAHNENSTIEL, G.L., SHUCHMAN, R.A., and WHITLEY, M., Michigan Tech Research Institute, 3600 Green Ct. Ste 100, Ann Arbor, MI, 48105, USA. **Satellite Derived Historical Trends of CyanoHAB Blooms in Three Eutrophic Basins of the Great Lakes.**

Blooms of harmful cyanobacteria (cyanoHABs) were mapped for western Lake Erie-WBLE, Green Bay-GB, and Saginaw Bay -SB from 2002-2013 using MODIS imagery. These blooms were compared to meteorological and environmental parameters to determine the importance of regional vs. local scale controlling factors. CyanoHAB trends were generated using two modified remote sensing approaches. The first is a modified chlorophyll retrieval algorithm enhanced with empirical relationships to estimate water column cyanoHABs (MCH) whereas the second approach uses near-infrared reflectance to quantify surface scums (SSI). Satellite cyanoHAB estimates agreed well with in situ observations. The annual MCH trends for WBLE, SB, and GB were not similar for the 2002-2013 period. Extensive surface scums were observed in WBLE but not in GB or SB. Meteorological parameters were similar among the basins, however significant differences in spring discharge (Q) of the dominant rivers were observed. Spring Q was a significant predictor of cyanoHABs in WBLE but not in GB and SB. Wind induced sediment re-suspension events were common during the bloom period in WBLE but not GB or SB and were highly correlated with cyanoHABs. These results suggest local factors are more important than regional factors in controlling cyanoHABs within these three basins. *Keywords: Harmful algal blooms, Lake Erie, Remote sensing, Saginaw Bay, Green Bay.*

SCHAEFFER, J.S., USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105, USA. **Reconciliation Ecology: a Tool for Enhancing Urban Coastal Habitats.**

Coastal managers have two primary tools to maintain habitats: preservation and restoration. But, this leaves out large portions of the urban coast where all native habitat has been lost, or places where novel conditions or processes preclude restoration. Therefore, what is needed is a way of maintaining nature within the urban coast. Reconciliation represents a novel tool that can overcome this dilemma by modifying the human landscape to support nature, but also provide benefits for the people who live in coastal cities. It has been applied widely in terrestrial environments, but only rarely in aquatic systems because it requires synthesis of ideas from three distinct paradigms: ecology, engineering, and landscape architecture. In my presentation, I discuss principles of reconciliation and illustrate real and potential applications in urban coastal environments. *Keywords: Coastal ecosystems, Restoration, Habitats.*

SCHIFF, S.L.[1], SHAFII, M.[1], BASU, N.B.[1], ELGOOD, R.J.[1], DOVE, A.[2], ANDERSON, M.[3], ENGLISH, M.[4], DURR, H.[1], RUDOLPH, D.L.[1], O'CONNELL, D.[1], and TAYLOR, W.D.[1], [1]University of Waterloo, Waterloo,, ON, N2L3G1, CANADA; [2]Environment Canada, Burlington, ON, L7R 4A6, CANADA; [3]Grand River Conservation Authority, , Cambridge, ON, N1R 5W6, CANADA; [4]WiIfrid Laurier University,, Waterloo, ON, N2L 3C5, CANADA. **Do Catchment Hotspots Control P & N Export To Lake Erie During An Extreme Snowmelt Event?**

The Grand River is the largest Canadian river feeding Lake Erie and is heavily impacted by both agricultural activities and the rapidly growing population that reside mostly

in urban centres. Contributions from the various agricultural subcatchments and from urban sources differ with season resulting in a distinctive but shifting pattern in nutrients along the length of the river. Snowmelt contributes disproportionately to nutrient loads. Prior to snowmelt in 2014, snow water equivalence in the basin exceeded records for the past 30 years. The north-south orientation of the watershed results is a time lag between snowmelt contributions from different portions of the catchment. Are the nutrient signals from various sources preserved during this extreme event? We sampled water chemistry including nutrients (TP, SRP, NO3-, NH4+) at a range of scales from small agricultural headwater catchments (2 km2) to the mouth of the 7th order Grand River over the snowmelt period. In addition, we completed two longitudinal samplings of the river over the entire 300 km on a single day. Here we examine both spatial and temporal nutrient concentrations at different scales and calculate the changing contributions of the various sources to export to Lake Erie.
Keywords: Nutrients, Watersheds, Lake Erie.

SCHNEIDER, K.D.[1], REID, D.K.[1], and MCCONKEY, B.G.[2], [1]Agriculture and Agri-Food Canada, 174 Stone Rd. West, Guelph, ON, N1G 4S9, CANADA; [2]Agriculture and Agri-Food Canada, 1 Airport Rd., Swift Current, SK, S9H 3S2, CANADA. **IROWC-P: A National Indicator to Predict the Risk of P Loss from Agricultural Soils to Surface Water.**

In Canada, P from agricultural sources has been implicated as a contributor to significant algal blooms in many shallow lakes, including Lake Erie, Lake Simcoe, Lake Winnipeg and Lake Champlain. There is a need to assess the risk of P loss from agricultural land in a way that takes into account both agricultural sources of P and unique physiographic features of the landscape that affect P transport. To address this need, the Indicator of Risk of Water Contamination - Phosphorous (IROWC-P) was originally developed by Agriculture and Agri-Food Canada using principles similar to the P Index which is used at the field scale in most US states. New data on P risk assessment and P loss that has recently come available provides the opportunity to update the science behind IROWC-P model structure and algorithms. This presentation will summarize how the science behind P loss risk assessment has evolved and outline the component approach we are taking to account for different sources of P loss (P loss from overland flow, incidental losses that occur from applied P, P leaching from vegetation over winter, subsurface drainage losses, and particulate P losses from erosion) that contribute to surface water contamination. It will also highlight key considerations for conducting P loss risk assessments at the landscape or watershed scale.
Keywords: Watersheds, Risk assessment, Modeling, Agriculture, Phosphorus, Non-point source.

SCHRYER, B., Ontario Federation of Anglers and Hunters, P.O. Box 2800, 4601 Guthrie Drive, Peterborough, On, K9J 8L5, CANADA. **Asian Carps: Prevention and Early Warning for the Canadian Great Lakes.**

With over 185 non-indigenous species established within the Great Lakes basin, there is a need to prevent the establishment of new invaders. The Invading Species Awareness Program (ISAP), in partnership with Fisheries and Oceans Canada (DFO) has been delivering a comprehensive education and outreach campaign for Asian Carps in the Canadian Great Lakes regions. The campaign has two main goals: 1) prevent the introduction of Asian Carps to the Canadian Great Lakes, and promote and 2) encourage early detection/warning of Asian Carps in the Canadian Great Lakes. The ISAP utilizes networks of key outlets/audiences, such as bait shops, marinas, municipalities, fishing charter operators, and tourist outfitters to distribute numerous educational materials promoting knowledge and awareness of Asian Carps, and encouraging potential sightings to be reported to the Invading Species Hotline, or via EDDMapS Ontario. By educating the public on the impacts of Asian Carps, how to identify these species, and how to report a possible sighting of this species, we can empower communities to help protect the Great Lakes watershed from an introduction of Asian Carps. *Keywords: Biodiversity, Asian Carps, Invasive species, Education, Outreach.*

SCOFIELD, A.E.[1], RUDSTAM, L.G.[1], and CARRICK, H.J.[2], [1]Cornell Biological Field Station, 900 Shackelton Point Road, Bridgeport, NY, 13030, USA; [2]Central Michigan University, Mount Pleasant, MI, 48859, USA. **Primary and Secondary Production Patterns in Southern Lake Michigan: Insights from CSMI 2015.**

Since the 1980s, significant reductions in nutrient inputs, growing populations of *Dreissena* mussels, and the introduction of nonnative predators such as *Bythotrephes* have contributed to major shifts in the distribution and structure of phytoplankton and zooplankton assemblages in Lake Michigan. Because of reduced epilimnetic nutrient levels and high water clarity, production in subsurface waters may augment the food web. This study reports major findings on lower trophic level dynamics from sampling in southern Lake Michigan during the CSMI intensive year in 2015. We observed a deep chlorophyll layer (DCL) during peak summer stratification in southern Lake Michigan, but it was limited to the western basin; production overall was higher in the eastern basin. The zooplankton community was dominated by calanoid copepods; greater diversity was observed in the eastern basin, where notable numbers of cyclopoid copepods, cladocerans grazers, and the invasive cladoceran *Bythotrephes* were observed. When a DCL was present, zooplankton are tapping into subsurface food resources, based on gut fluorescence analysis, bottle enclosure experiments, and stratified net tow data. This study underscores the spatial complexity in phytoplankton distribution that appears to augment secondary production in southern Lake Michigan. *Keywords: Lake Michigan, Deep Chlorophyll Layer, Productivity, Phytoplankton, Zooplankton.*

SELEGEAN, J.P. and CALAPPI, T.J., U.S. Army Corps of Engineers, Great Lakes Hydaulics and Hydrology Office, Detroit, MI, MI, 48226, USA. **On the origins of the aggradation at the mouth of the Ahnapee River in Lake Michigan.**

Chronic aggradation at the mouth of the Ahnapee River in Lake Michigan at Algoma, WI has crippled navigation at this harbor. This study examined many sets of data including sediment samples and hydrodynamic data to identify the source of sediment to the marina and outer harbor. The two most likely sources of sediment were from the Ahnapee River and the littoral zone (beach and lake bed). Twenty one sediment samples were collected from the Ahnapee River and the littoral zone and then compared to that found in the marina. The samples were analyzed for organic matter content, gradation, color, specific gravity, angularity, presence of frosting, reaction with acid and the extent of shell presence. The mineralogy of the samples was also determined using X-ray diffraction. An assessment of the hydrodynamic conditions was made with a series of GPS drogues, and the permeability of the structure was assessed with underwater video. The mineralogy results provided compelling evidence that the inorganic portion of shoaled material in the outer harbor originated from the Ahnapee River rather than from the littoral zone.
Keywords: Sediment transport, Hydrodynamics.

SENAR, O.E.[1], CREED, I.F.[1], KIDD, K.[2], and TRICK, C.G.[3], [1]Department of Geography, Western University, 1151 Richmond St, London, ON, N6A 3K7, CANADA; [2]Department of Biology, University of New Brunswick, 100 Tucker Park Road, St. John, NB, E2L 4L5, CANADA; [3]Department of Biology, Western University, 1151 Richmond St, London, ON, N6A 3K7, CANADA. **Dissolved organic matter promotes cyanobacterial dominance in oligotrophic lakes.**

Dissolved organic matter (DOM) is a mixture of compounds with different chemical properties and susceptibility to biological breakdown. In lakes with high concentrations of labile DOM, heterotrophic bacteria dominate incorporating terrestrial carbon into the aquatic food web. In contrast, in lakes with relatively high concentrations of refractory DOM, bacterial productivity is low. As a result, the refractory DOM can influence competition among primary producers by modulating nutrient availability. Our survey of 46 oligotrophic lakes in the Great Lakes watershed presenting a range of DOM quality set out to define the DOM conditions that promote cyanobacterial growth. We characterized DOM using Excitation Emission Matrices, and used stable isotopes to determine the main carbon source of zooplankton. As DOM conditions changed from refractory to labile, zooplankton diet shifted from phytoplankton (autochthonous carbon) to heterotrophic bacteria (allochthonous carbon), and there was a concurrent increase in the proportion of cyanobacteria in the phytoplankton community. These findings suggest that cyanobacteria have a competitive advantage at intermediate DOM quality characteristics, supporting the conceptual model that cyanobacteria can access nutrients that are not tightly bound to DOM. *Keywords: Dissolved organic matter, Cyanophyta, Food chains.*

SHAFII, M.[1], BASU, N.B.[1], SCHIFF, S.L.[1], ELGOOD, R.J.[1], MACRAE, M.L.[2], ENGLISH, M.[3], and VAN CAPPELLEN, P.[1], [1]Department of Earth & Environmental Sciences, University of Waterloo, 200 University Av W, Waterloo, ON, N2L3G1, CANADA; [2]Geography and Environmental Management, University of Waterloo, 200 University Av W, Waterloo, ON, N2L3G1, CANADA; [3]Wilfrid Laurier University, University Av W, Waterloo, ON, N2L3C5, CANADA. **Modeling Stream Nitrate Concentrations in a Snow-dominated Catchment in Southwestern Ontario.**

The Grand River Watershed (GRW) is the largest basin in Southwestern Ontario feeding into the Lake Erie, with severe nitrate contamination issues, especially during the winter snowmelt events. High inputs of nutrients due to intensive agriculture and a dense tile drainage system are among factors contributing to the pollution of surface water in this watershed. GRW is a snow-dominated catchment, and the largest nitrate fluxes are during the snowmelt events. To get an insight into the hydrologic and biogeochemical response, we focused on multiple subwatersheds in the GRW in which such data have been collected by various researchers over time. A unique hydrological flow partitioning methodology was used to constrain flow pathways in the hydrology model, which is critical to the accurate representation of the sources and sinks in the biogeochemical model. We also employed a novel signature-based multi-criteria calibration approach where the search for desirable parameter values is guided by the similarity between simulated and observed signatures. Following this, a biogeochemical model was developed to simulate catchment-scale nitrate transport at a variety of spatio-temporal scales. This ecohydrological model will be used to provide management options for nitrate delivery to the Lake Erie. *Keywords: Biogeochemistry, Multicriteria calibration, Modeling, Hydrologic partitioning, Watersheds.*

SHAO, H.[1], YANG, W.[1], LINDSAY, J.[1], LIU, Y.[1], YU, Z.Q.[2], and OGINSKYY, A.[3], [1]University of Guelph, 50 Stone Road East, Guelph, ON, N1G 2W1, CANADA; [2]Civica Infrastructure, 330 Rodinea Road, Unit 3, Vaughan, ON, L6A 4P5, CANADA; [3]Alberta Agriculture and Forestry, Economics Branch, 7000-113 Street, Edmonton, AB, T6H 5T6,

CANADA. **An Open Source GIS-based Decision Support System for Watershed Evaluation of BMPs.**

Economic costs, water quantity/quality (WQQ) benefits, and cost effectiveness of agricultural best management practices (BMPs) at a watershed scale are increasingly examined using integrated economic-hydrologic models. However, these models are typically complex and not user-friendly to examine various BMPs scenarios. In this study, an open source GIS-based decision support system (DSS), named the Watershed Evaluation of BMPs (WEBs) interface, was developed for creating BMP scenarios and simulating economic costs and WQQ benefits at field and watershed scales. This DSS integrates the Soil and Water Assessment Tool (SWAT), BMP on-farm economic models, and databases within an open-source GIS system (Whitebox GAT). The DSS was applied to the 15-km^2 Gully Creek watershed in the shoreline areas of Lake Huron. BMPs evaluated include conservation tillage, fertilizer management, cover crop, and water and sediment control basins (WASCOBs). In addition to assess BMP economic costs, environmental benefits, and cost effectiveness, the DSS can also be used to examine prioritized BMP types/locations and corresponding economic and environmental tradeoffs based on environmental targets and economic constrains. Further improvements, such as system structure, database management, system transfer and scale-up, are also discussed. *Keywords: GIS, Decision support system, Modeling, SWAT, Water quality, BMP.*

SHAPIERA, M.[1], WOZNEY, K.[2], FREELAND, J.R.[3], and WILSON, C.C.[2], [1]Ontario Ministry of Natural Resources and Forestry, Aurora District, 50 Bloomington Rd., Aurora, ON, L4G 0L8, CANADA; [2]Ontario Ministry of Natural Resources and Forestry, Aquatic Research and Monitoring Section, 1600 West Bank Dr., Peterborough, ON, K9L 0G2, CANADA; [3]Trent University, 1600 West Bank Drive, Peterborough, ON, K9L 0G2, CANADA. **Integrative monitoring and rapid response to Water Soldier (Stratiotes aloides) in the Lake Simcoe watershed.**

The early detection of invasive species, and a subsequent rapid response, are crucial for successfully preventing their establishment. In October 2015, Water Soldier (*Stratiotes aloides*) was discovered by the Ministry of Natural Resources and Forestry (MNRF) in the Black River, Ontario; only the second known population in North America. If unchecked, Water Soldier can dominate established ecosystems due to its fast biomass production in clonal colonies, as witnessed in the Trent River. A rapid response to prevent establishment and potential spread to Lake Simcoe, involving mechanical removals and herbicide treatment, was launched by the MNRF in October-December 2015. Samples of environmental DNA (eDNA) were taken at the site and along the waterway before and after herbicide treatment to assist in detecting potential satellite populations and monitoring the effectiveness of eradication efforts. Timing of eDNA sampling proved critical in avoiding false positives and negatives cause by environmental variables such as water flow, high organic matter concentrations, and high suspended sediment levels. Further comprehensive monitoring is necessary to determine if eradication was successful and to prevent establishment in the Lake Simcoe watershed. *Keywords: Lake Simcoe, Invasive species, Genetics.*

SHARMA, S.[1], MAGNUSON, J.J.[2], BATT, R.D.[2], and WINSLOW, L.[2], [1]York University, Toronto, ON, CANADA; [2]University of Wisconsin-Madison, Madison, WI, USA. **Direct observations of ice seasonality reveal changes in climate over the past 320-570 years.**

Lake ice is a sensitive indicator of climate change and variability. Climate change, large-scale climate drivers, and weather are all important drivers of ice freeze and breakup dates for Lake Suwa, Japan from 1443-2004 and Tornio River, Finland from 1693-2013. Using long-term records, we identify a regime shift in ice freeze and breakup coinciding with the start of the Industrial Revolution, the end of the Little Ice Age, and increases in atmospheric CO2 concentrations and air temperatures. In the past century relative to earlier centuries, we observed earlier ice breakup, later ice freeze, a doubling to tripling in the rates of change in the timing of ice freeze and breakup, decreased importance of very short-term or long-term oscillatory dynamics for Tornio River, and increased proportions of warm extremes. Although local factors, including human population growth, land use change, and water management influence Suwa and Torne, the general patterns of ice seasonality are similar for both systems, suggesting that global processes including climate change and variability are driving the long-term changes in ice seasonality. *Keywords: Ice, Climate change, Climatic data.*

SHERMAN, J.J.[1], BOSSENBROEK, J.M.[1], CRAIL, T.[1], MAYER, C.M.[2], BOASE, J.[3], CHIOTTI, J.[3], and VANDERGOOT, C.S.[4], [1]Department of Environmental Sciences, University of Toledo, 2801 W. Bancroft St., Toledo, Oh, 43606, USA; [2]University of Toledo Lake Erie Center, 6200 Bay Shore Rd, Oregon, OH, 43616, USA; [3]U.S. Fish and Wildlife Service, Alpena Fish and Wildlife Conservation Office, 480 West Fletcher Street, Alpena, MI, 49707-2838, USA; [4]Department of Natural Resources - Division of Wildlife/ Sandusky Fisheries Research Station, 305 East Shoreline Dr., Sandusky, OH, 44870, USA. **A habitat suitability model for possible lake sturgeon reintroduction in the Maumee River.**

Lake sturgeon are a candidate for reintroduction in the Maumee River where they were historically abundant but are currently absent from the system. In order to determine if current habitat quantity and quality are sufficient to support reintroduction, we constructed a spatially explicit habitat suitability model for spawning adult and age-0 lake sturgeon for the lower Maumee River. Habitat layers include substrate composition, water depth, water velocity, water quality characteristics, and habitat size and connectivity. A combination of survey methods including side scan sonar, visual observation, and benthic grabs were used to assess substrate composition while data loggers and a multi-parameter sonde measure a suite of water quality characteristics. Each habitat characteristic is mapped as a spatially explicit layer in ArcGIS and then combined to provide an overall assessment of habitat suitability and connectivity. Habitat suitability is delineated as good, moderate, or poor. Preliminary analysis of just substrate and water depth suggest that 27% and 58% of the Maumee River is classified as good for spawning adults and age-0 lake sturgeon, respectively. This model will aid the development of a restoration plan for potential reintroduction of lake sturgeon into the Maumee River. *Keywords: Sturgeon, Fisheries, Restoration, Habitats, Modeling, HSI.*

SHIMODA, Y.[1], KIM, D.K.[1], MUGALINGAM, S.[2], and ARHONDITSIS, G.B.[1], [1]University of Toronto Scarborough, Department of Physical & Environmental Sciences, 1265 Military Trail, Toronto, ON, M1C 1A4, CANADA; [2]Lower Trent Conservation, 714 Murray Street, Trenton, ON, K8V 5P4, CANADA. **Development of an Ensemble of Models for Predicting Eutrophication in the Bay of Quinte.**

The Bay of Quinte, a Z-shaped embayment at the northeastern end of Lake Ontario, represents a characteristic case, where scientific uncertainty underlies the current management efforts to integrate environmental concerns with socioeconomic values. This uncertainty exists despite one of the longest continuing research and monitoring programs of any site in the Great Lakes. The present study presents a network of eutrophication models (structural equation model, mechanistic model, evolutionary algorithms) in the Bay of Quinte, integrated with Bayesian inference techniques, which is used: (i) to elucidate the key factors associated with the phytoplankton-zooplankton interactions and the occurrence of phytoplankton blooms; (ii) to estimate the critical nutrient loads based on acceptable probabilities of compliance with different water quality targets (e.g., chlorophyll a, total phosphorus); (iii) to elucidate the interplay among different ecological mechanisms that drive the internal nutrient loading in the system; (iv) to optimize the sampling design, where spatio-temporal variation will be captured in future monitoring programs; and (v) to illustrate a methodological framework that is in alignment with the policy practice of adaptive management. *Keywords: Artificial Neural Networks (ANNs), Cyanophyta, Structural Equation Modeling (SEMs), Bay of Quinte, Ecosystem forecasting.*

SHIRANI, S. and HELLWEGER, F.L., Northeastern University, 360 Huntington Ave, Boston, MA, 02115, USA. **The role of neutral evolution in the biogeography of cyanobacteria populations of lake systems.**

Genomic observations of cyanobacteria reveal substantial biogeographic patterns within systems of connected lakes. An important question is the relative role of environmental selection and neutral processes in the biogeography of these systems. Here we quantify the role of genetic drift (neutral evolution) by simulating individual cyanobacteria cells using an agent-based modeling (ABM) approach. Cells grow (divide), die and migrate between lakes. Each cell has a 1Mbp genome that is subject to neutral mutation (i.e. the growth rate is independent of the genome). The model is verified by simulating simplified lake systems, for which theoretical solutions are available (e.g. stepping-stone model with uniform population sizes and migration rates). Then, it is used to simulate a number of real systems, including the Great Lakes, the Klamath River, the Yahara River and the Chattahoochee River. The emergent patterns of nucleotide divergence are dynamic, including gradual increases due to mutations and abrupt changes due to population takeovers by migrant cells (coalescence events). The model predicts substantial nucleotide divergence between lakes. *Keywords: Agent-based modeling, Biogeography, Cyanophyta.*

SHORE, J.A.[1], VALIPOUR, R.[2], and RICHARDS, A.[2], [1]Royal Military College of Canada, Kingston, ON, CANADA; [2]NWRI-Environment Canada, Burlington, ON, CANADA. **Twenty-eight Years of Hydrodynamic Variability in the Bay of Quinte.**

The Bay of Quinte contains critical wetland nurseries for Lake Ontario's walleye and yellow perch fisheries which are essential to the local million dollar fishing industry. While ecosystem modelling has thrived for this region, numerical modelling of the physical environment has lagged behind. A two-year simulation of the bay has recently been produced, but long term simulations will help to establish baselines for future changes and provide valuable information for ecosystem management. We have used a 3-d unstructured ocean model to illustrate the seasonal evolution of the bay's circulation and water properties for the period of 1979-2006. Modelled surface temperatures indicate that the bay is warming at a rate of 0.012 to 0.027 C per year. The main channel of the bay flushes about 5 times per year but this value varies considerably for different parts of the bay. Flushing times are generally governed by accumulative river inflows, and these times vary seasonally, interannually and spatially. The flushing time was parameterized as a function of mean annual river discharge, and showed that a minimum annual Trent river discharge of 64 m^3/s is required to flush out the head of the bay at least once a year. *Keywords: Bay of Quinte, Model studies, Water currents.*

SHORT, M., MIRZA, S., SHORT, C., STANIEWSKI, M., and LONG, A., University of Toronto, Toronto, ON, L5L1C6, CANADA. **A Newly Isolated Algal Virus Cultivated from the Bay of Quinte Infects the Haptophyte Chrysochromuli.**

Studies of algal virus diversity in Lake Ontario and a University of Toronto Mississauga (UTM) campus pond led to the detection of PCR amplicons closely related to viral genes infecting marine prymnesiophytes including Chrysochromulina brevifilum. These observations prompted us to screen samples for lytic activity against C. parva to determine if this primary producer is susceptible to virus infection. Phylogenetic analysis of polB gene fragments demonstrated that they were most closely related to genes from cultivated phycodnaviruses and TEM revealed numerous 145 nm icosahedral particles within the cytoplasm of infected cells. It appeared that this lytic agent (CpV-BQ1) belongs to Phycodnaviridae. However, with a large genome of ~485 kb and several major capsid protein genes that cluster with either phycodnaviruses or mimiviruses, we speculate that CpV-BQ1 could represent an evolutionary intermediate between Phycodnaviridae and Mimiviridae. Analyses revealed stable CpV-BQ1 coexistence rather than host-parasite oscillations. Viral decay rates ranged from 10 to 0.08 % per day in the summer and winter months, respectively, and after 126 d in a frozen pond 1.0 % of the CpV-BQ1 infectious titre remained. Our data demonstrates that CpV-BQ1, a unique seasonally persistent virus, plays an important role in freshwater food webs. *Keywords: CpV-BQ1, Algal virus, Lake Ontario, Phycodnaviridae.*

SHUCHMAN, R.A.[1], SAYERS, M.[1], SAWTELL, R.[1], and LESHKEVICH, G.[2], [1]Michigan Tech Research Institute, 3600 Greet Ct., Ann Arbor, MI, 48105, USA; [2]NOAA-GLERL, 4840 S. State Rd., Ann Arbor, MI, 48108, USA. **Phytoplankton Group Determination using Hyperspectral Remote Sensing in Western Lake Erie.**

Determination of phytoplankton groups (green algae, diatoms, cryptophytes, and cyanobacteria) in natural water bodies is important information for many stakeholders including scientists, water intake managers, and recreational users. These determinations can be made in the field using fluorescence instrumentation or in the laboratory using microscopy and particle imaging. There is potential to determine phytoplankton groups from remote sensing hyperspectral data measured on the ground, in the air, and from space. Remote sensing provides the unique ability to provide synoptic coverage of a water body without the need to be in the field. These techniques rely on the ability to detect specific spectral absorption features associated with different pigments that vary with phytoplankton group. An extensive data set was collected from May-October 2015 in western Lake Erie that included weekly coincident measurements of phytoplankton composition and water surface reflectance. This robust data set was used to evaluate and generate remote sensing

based phytoplankton classification approaches with variable success. Supervised classification methods were able to determine the dominant phytoplankton type from others (cyanobacteria vs. diatoms) while complex machine learning techniques could differentiate types and concentrations. *Keywords: Remote sensing, Lake Erie, Harmful algal blooms.*

SHUNTHIRASINGHAM, C.[1], HUNG, H.[1], ALEXANDROU, N.[1], BRICE, K.A.[1], SU, K.[1], DRYFHOUT-CLARK, H.[1], GAWOR, A.[1], PAJDA, A.[1], SHIN, C.[1], PARK, R.[1], and NORONHA, R.[1], [1]Air Quality Processes Research Section, Environment and Climate Change Canada, 4905 Dufferin St, Toronto, ON, M3H 5T4, CANADA; [2]Air Quality Processes Research Section, Environment and Climate Change Canada, 6842 Eighth Line, Egbert, ON, L0L 1N0, CANADA. **Temporal Trends of SVOCs in the Canadian Great Lakes Basin.**

Organic contaminants continue to persist in the Great Lakes Basin (GLB) and remain a threat to human health and the environment. Industrial and commercial chemicals such as polychlorinated biphenyls (PCBs) and, polybrominated diphenyl ethers (PBDEs); chlorinated pesticides and other emerging organic chemicals have been found in the atmosphere of the GLB. High volume (HiVol) air samples were collected between 1992 and 2012 at two Canadian operated master stations (Point Petre and Burnt Island) and a satellite station (Egbert). The extracts were analyzed for PCBs and chlorinated pesticides. In addition to HiVol air sampling, XAD-passive air samplers (PASs) and PUF-PASs were deployed side-by-side at four satellite stations since 2014. Extracts from both PASs were analyzed for a wide range of pesticides, PCBs, and PBDEs. In this study, we compared the results of the two passive air sampling techniques under temperate climate conditions in the GLB region for different compound classes. Long-term trends of PCBs and legacy chlorinated pesticides in air in the GLB were also examined using results from Hivol measurements. Long-term declining trends were observed for both chlorinated pesticides and PCBs; air concentrations of PCBs are declining very slowly, compared to chlorinated pesticides. *Keywords: Spatial distribution, Temporal trend analysis, Toxic substances.*

SIMARD, L.G.[1], MARSDEN, J.E.[1], BIGELOW, P.E.[2], and GRESSWELL, R.E.[3], [1]University of Vermont, 3 College Street, Burlington, VT, 05401, USA; [2]National Park Service, Center for Resources, Yellowstone National Park, WY, 82190, USA; [3]U.S. Geological Society, 2327 University Way, Suite 2, Bozeman, MT, 59715, USA. **Can Suppression Inform Restoration? Insights from Lake Trout in Yellowstone Lake.**

Lake trout (Salvelinus namaycush) are the focus of both restoration and suppression efforts across their current range. The species was discovered in Yellowstone Lake in 1994 and are the focus of an intensive gillnet suppression program. A current focus of the program is to determine whether targeting early life stages would augment suppression. Prior to the implementation of any early life stage control, the location and physical characteristics of spawning sites must be determined. Low species diversity and absence of interstitial egg predators in Yellowstone Lake may impose different constraints on spawning site choice than in the Great Lakes, creating uncertainty about site characteristics and utilization. A benthic sled was used to sample 30 sites for lake trout eggs, encompassing a range of depth, slope, and substrate composition. Lake trout eggs were collected at six sites, four of which had not been previously confirmed as spawning sites. Preliminary results suggest lake trout spawning is limited to rocky areas in Yellowstone Lake, but is not constrained by presence of interstitial spaces. This information will help Yellowstone managers identify additional spawning sites and aid suppression, but will also help restoration efforts in the Great Lakes by broadening our knowledge of lake trout spawning requirements. *Keywords: Habitats, Invasive species, Lake trout.*

SIMMONS, D.B.D.[1], SHERRY, J.P.[1], MUIR, D.[1], CHANDRAMOULI, B.[2], and COSGROVE, J.R.[2], [1]Environment Canada, Water Science and Technology, Burlington, ON, CANADA; [2]AXYS Analytical Services Ltd., 2045 Mills Road West, Sidney, BC, CANADA. **The proteome and metabolome of plasma from caged goldfish deployed in Cootes' Paradise.**

Cootes Paradise is part of the Hamilton Harbour Area of Concern on Lake Ontario. It is an important site of biological diversity and fish nursery. The primary source of contaminants flowing into Cootes Paradise is from Dundas municipal sewage treatment plant (STP) effluent. Dundas STP effluent contributes up to 80% of the water flow through Cootes Paradise during periods of low precipitation and the plant was recently upgraded. To assess the endocrine disrupting potential of Dundas STP effluents to wild goldfish in Cootes paradise, male goldfish were housed in cages (5/cage, 5 cages/site) at three sites in Cootes Paradise, along a contamination gradient, and also at a reference site in Lake Ontario, Jordan Harbour. Cages were deployed for 21 days (June 25/26 - July 16/17 2014). Shotgun proteome and targeted endogenous metabolite profiles were determined using goldfish plasma from the caging exposure and also in 20 male wild goldfish which were captured from Cootes Paradise in 2012. The expression of 26 proteins and 109 metabolites were significantly affected by sampling location in the caged fish. In this presentation we will explore the biological functions related to observed changes in protein and metabolite expression patterns, and relate them to expression changes in the plasma of wild fish collected previously. *Keywords: Hamilton Harbour, Sewage treatment plant effluent, Fish, Environmental effects.*

SIMOLIUNAS, S., DARRAH, C., DOUGHERTY, C., MCDONALD, S., and WELCH, I., Great Lakes Water Protection Committee, 665 W. Warren Avenue, Detroit, MI, 48201, USA. **The Road Not Taken by Great Lakes Water Authority.**

Great Lakes Water Authority was organized by mediation in federal district court. It is made up of two policemen from Detroit, two accountants from Macomb and Oakland counties, one airport official from Wayne county, one retired attorney from governor's office. GLWA took over most of the functions of Detroit Water and Sewerage Department on January 1, 2016. It kept the same administration. Great Lakes Water Protection Committee was established a year before. It tried to influence GLWA by public comment, communications, scientific papers, but was ignored all the time. The same response was obtained by other environmentalists. GLWA is the largest polluter of Great Lakes.

Keywords: Great Lakes basin, Detroit River, Pollution load.

SIMONSON, M.A.[1], QIAN, S.S.[1], MAYER, C.M.[1], AREND, K.K.[2], and WEIMER, E.J.[3], [1]University of Toledo - Lake Erie Center, Toledo, OH, USA; [2]Ohio DNR - Old Woman Creek NERR, Huron, OH, USA; [3]Ohio DNR Division of Wildlife, Sandusky, OH, USA. **Identifying Relationships Between the Lake Erie Coastline and the Nearshore Fish Community.**

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 the linkage between aquatic and terrestrial habitats. Therefore, we hypothesized that varied shoreline features such as terrestrial vegetation and types of erosion control may affect the nearshore fish community composition. In order to determine relationships between shoreline types and the nearshore fish community, terrestrial vegetation and shoreline structures were classified at coastal sites in the western basin of Lake Erie where fish were sampled between 2011 and 2015. Indices of the nearshore fish community were compared to shoreline habitat classifications. Highest species richness was associated with vegetated shorelines that are structurally complex, while lowest species richness occurred along homogeneous shorelines without vegetation. Unarmored shorelines with mixed vegetation had the highest relative abundances of native fish species. The influence of coastal landscape characteristics on nearshore ecosystem services must be accounted for in urban planning of sustainable coastal communities.

Keywords: Armoring, Lake Erie, Nearshore, Coastal ecosystems, Littoral zone.

SIMPKINS, D.G. and STRAKOSH, T.R., U.S. Fish and Wildlife Service Green Bay Fish and Wildlife Conservation Office, 2661 Scott Tower Drive, New Franken, WI, 54229,

USA. **Influence of River Plumes on Distribution, Composition and Structure of Nearshore Lake Michigan Fish.**

As part of the 2015 Cooperative Science and Monitoring Initiative, the U.S. Fish and Wildlife Service sampled shallow-water (< 18m) habitats in Lake Michigan to test the hypothesis that river plumes influence the occurrence, distribution, and structure of near-shore fish communities. Our objectives were to: 1) Describe spatiotemporal patterns in community composition, distribution, and size-structure of near-shore fishes within plumes emitted by large rivers; 2) Compare community composition, distribution, and size-structure of near-shore fishes within plumes to areas adjacent to - and without plumes; and 3) Assess the influence of large river plumes on fish community metrics and presence of invasive aquatic species in Lake Michigan. Spatiotemporal differences were evident, with higher catches and diversity of small bodied fishes associated with proximity to river plumes, especially in southern areas. No new aquatic invasive species were collected, but previously established invasive species tended to be larger and more numerous near river plumes. Our findings suggest that river plumes influence the distribution of near-shore fishes and may provide a favorable environment for invasive fish. *Keywords: Invasive species, Biomonitoring, Lake Michigan.*

SIMPSON, A.J., SOONG, R., LIAGHATI MOBARHAN, Y., AKHTER, M., LANE, D., FORTIER-MCGILL, B., SIMPSON, M.J., and ARHONDITSIS, G.B., University of Toronto Scarborough, Dept. Physical and Environmental Science, 1265 Military Tr., Toronto, ON, M1C1A4, CANADA. **Elucidating Environmental Stress through *in-vivo* NMR spectroscopy.**

Present environmental policies are set primarily based on the acute toxicity of individual chemical species, however, additional molecular-level information is desperately needed to help understand risks associated with sub-lethal toxicity of individual compounds and mixtures. This is stressed in an report "Toxicity Testing in the 21st Century" (EPA) which states *"The new paradigm should facilitate evaluating the susceptibility of different life-stages, understanding the mechanisms by which toxicity occurs, and considering the risks of concurrent, cumulative exposure to multiple and diverse chemicals"*. Nuclear Magnetic Resonance (NMR) is one of the most powerful tools in modern research and unlike most analytical approaches can be applied in-vivo. This research aims to develop a novel combined flow and multi-phase NMR framework to measure contaminant behavior (binding, biotransformation, dynamics etc.) and directly relate this to environmental stress (measured via the *in-vivo* metabolic fingerprint). The results provide a detailed understanding explaining, how and why certain chemicals and mixtures are toxic as well as identify subtle detrimental effects (i.e. permanent binding or transformation into reactive intermediates) currently challenging to measure. *Keywords: In-vivo metabolites, Environmental health, NMR Spectroscopy, Bioindicators, Toxic substances.*

SINE, S.E.[1], SCHIFF, S.L.[1], CUMMINGS, F.[1], ELGOOD, R.J.[1], and VENKITESWARAN, J.J.[2], [1]University of Waterloo, Waterloo, CANADA; [2]Wilfrid Laurier University, Waterloo, CANADA. **Paradigm Shift: Does River Metabolism Mask the Isotopic Signal of Nitrate Sources?**

Nitrate is the most ubiquitous contaminant in surface and groundwaters in Canada. Synthetic fertilizers application and manure production in intensive agricultural areas contribute large quantities of nitrate to the landscape with a proportion lost to groundwaters and streams depending on season. Elevated nitrate in freshwater systems can result in problems for drinking water supplies and aquatic ecosystem health. Isotopes of nitrate are commonly used in ecosystem studies to apportion sources (e.g. manure, septic systems and synthetic fertilizers) and to determine the important N cycling processes and associated rates. For decades, several assumptions have governed these studies such as: the $\delta^{18}O$ of nitrate is conservative in oxic environments and the $\delta^{18}O$ of nitrate from nitrification can be predicted using the 1:2 rule. However, recent research suggests that these assumptions may not always be correct. Our research indicates that internal N recycling in riverine systems can be rapid, and the effect of the isotopic signal of nitrate cannot be ignored. Incubation experiments and in-river chamber experiments showed that the $\delta^{18}O$ of nitrate is not conservative and recycling rapidly "resets" the $\delta^{18}O$ to that of water in a large impacted river in southern Ontario. *Keywords: Drinking water, Nitrogen cycle, Grand River, Nitrate sources, Isotope studies.*

SINGH, A.[1], AUGER, S.[2], and VAN SETERS, T.[3], [1]Credit Valley Consrvation, 1255 Old Derry Road, Mississauga, ON, l5n6r4, CANADA; [2]Lake Simcoe Region Conservation Authority, 120 Bayview Parkway, Newmarket, On, L3Y 3W3, CANADA; [3]Toronto and Region Conservation, 9520 Pine Valley Drive, Vaughan, On, L4L 1A6, CANADA. **Development of a Low Impact Development and Urban Water Balance Modeling Tool.**

The TRCA, LSRCA, and CVC (GTA CAs) will present on their collaborative efforts to identify preferred Low Impact Development (LID) Stormwater Management (SWM) models suitable for meeting typical design criteria. The GTA CAs research will inform the audience of model criteria and rationale that supports the selection of preferred LID modelling tool(s) which effectively demonstrate design targets have been met. This presentation will also overview the strategy moving forward with the development of an LID Treatment Train Tool (LIDTTT) for Ontario and highlight the status of a Beta version,

under development in 2016. This primary intention of the LIDTTT is to support LID opportunities for a proposed site plan, throughout the design process undertaken by planners, SWM designers, and other decision makers for all types of site development or retrofit projects. The development of the LIDTTT will process computational results from EPA-SWMM, to provide an assessment of stormwater runoff volume and associated target depths, along with total suspended solids (TSS) and total phosphorus (TP) reductions for both annual and event based scenarios, throughout the design process. An update of state of the Beta version of the LIDTTT will be provided, along with a demonstration of the Beta version of the LIDTTT. *Keywords: Urbanization, Storm Water Management, Modeling, Low Impact development, Water quality.*

SIWULA, P.J., WINTER, C.L., THOMPSON, M.A., ARMSTRONG, M.R., and LABUHN, S.L., University of Milwaukee School of Freshwater Sciences, 600 E. Greenfield Ave., Milwaukee, WI, 53204, USA. **Dissolved Oxygen and Primary Productivity of a Neotropical Freshwater Ecosystem.**

Situated in the Southern Yucatan peninsula of Mexico, Laguna Bacalar represents an opportunity to study the dynamics and productivity of a unique freshwater system that may be susceptible to eutrophication due to increasing development in the surrounding area. Primary productivity was assessed via a light-dark bottle incubation experiment with nutrient additions of ammonium nitrate and phosphate as well as using in situ diel oxygen cycles. For light-dark bottle experimentation dissolved oxygen content was measured in the morning and in the evening after bottles were incubated in the lake during the daylight hours. Dissolved oxygen content increased when an aliquot of lake water was inoculated with nutrients and allowed to incubate for 4 days prior to light-dark bottle experimentation. Net primary productivity (NPP) assessment of aliquot-incubated samples showed an increase of 18.55 mmol m^{-3} hr^{-1} in samples with spiked with phosphate, an increase of 0.19 mmol m^{-3} hr^{-1} in samples spiked with ammonium nitrate, and an increase of 48.3 mmol m^{-3} hr^{-1} in samples spiked with both phosphate and ammonium nitrate. These results suggest that phosphorus is a limiting nutrient for this freshwater system. *Keywords: Neotropical, Yucatan, Eutrophication, Oxygen, Productivity.*

SLONE, L.A., MCCARTHY, M.J., MYERS, J.A., and NEWELL, S.E., Wright State University, 3640 Colonel Glenn Hwy., Dayton, Oh, 45435, USA. **Can Lower Great Miami River Sediment Compensate for Nutrient Over-enrichment?**

The Great Miami River has experienced algal blooms in recent years due to excess nitrogen (N) and phosphorus (P). Some Ohio water treatment plants have been ordered to

reduce the P that they release into the Lower Great Miami River (LGMR), but N also can stimulate blooms. In this study, N removal and recycling rates within LGMR sediments were compared with N loads during low and high flow conditions. Sediment ammonium (NH4+) flux, sediment N sinks and sources (denitrification/anammox and N fixation, respectively), and potential dissimilatory nitrate reduction to ammonium (DNRA) were evaluated. Duplicate cores from each site were incubated in a continuous-flow system with additions of either 15NO3-, 15NH4+, or left unamended (control). Preliminary results suggest that LGMR sediments function as a strong N sink, with very high rates of denitrification during high and low flow conditions. In contrast, LGMR sediments were a source of NH4+ and P, which may support continued algal blooms. These results suggest that LGMR sediments can remove a large proportion of watershed N loads, but they also can return nutrients to the water column where they can fuel additional production and eutrophication.
Keywords: Eutrophication, Nutrients, Sediments.

SMITH, J.P.[1], HUNTER, T.S.[2], SLAWECKI, T.[3], and RUBERG, S.A.[2], [1]Cooperative Institute for Limnology and Ecosystems Research, G110 Dana Building, 440 Church St., Ann Arbor, MI, 48109-1041, USA; [2]NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Rd., Ann Arbor, MI, 48108-9719, USA; [3]LimnoTech, 501 Avis Dr., Ann Arbor, MI, 48108, USA. **Tools of the data Smithe's trade.**

When discussing the management of large amounts of data, a topic that may frequently come up is the front-end or interface to such data. Multiple strategies and tools exist to construct pipelines from the data's source to users and viewers' computer screens. A few tools and strategies, however, stand out. This talk will discuss a variety of strategies and stand-out technologies - some emerging, some that have otherwise been around for decades. The focus will be less on field equipment, and more on those tools and strategies that take the raw monitoring data from the field to the user interface. *Keywords: Observing systems, Data storage and retrieval, Monitoring, Remote sensing, Data acquisition, Informatics.*

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. **More than Microcystins? Analytical Methods for Paralytic Shellfish Toxins in the Great Lakes.**

Most research on Harmful Algal Blooms in Lake Erie has focused on the occurrence of microcystins. However, Lake Erie has a rich diversity in its cyanobacteria flora and thus may have a sizable presence of other cyanobacterial toxins. Paralytic Shellfish Toxins (PSTs) are produced by members of the genus Anabaena and Lyngbya - both common members of the Lake Erie flora, and have been widely identified within the State of Ohio. To develop a robust monitoring program for the occurrence of PSTs in the Great Lakes basin and New York State, we examined three different methods for measurement of PSTs in freshwaters. These include (1) the traditional HPLC with post-column oxidation and fluorescent detection developed by Oshima, (2) newer HILIC chromatography methods coupled with mass spectroscopy (MS or MS/MS) detection, and (3) commercially available ELISA assays for PSTs. Known PST-producing cyanobacteria were grown in laboratory culture, and water samples were collected from more than 125 lakes spread across New York. Samples were extracted using a unified sample extraction protocol and analyzed using all three methods. A comparison of the three different methods will be presented. *Keywords: Cyanobacteria toxins, Paralytic shellfish poisoning.*

SMITH-EDWARDS, S.[1], MARTIN, P.[2], LINK, J.[1], LETCHER, R.J.[3], NEWSTED, J.L.[1], and BURSIAN, S.[1], [1]Michigan State University, Department of Animal Sciences, Michigan, MI, 48823, USA; [2]Environment Canada, Ecotoxicology and Wildlife Health, Burlington, ON, CANADA; [3]Environment Canda, Ecotoxicology and Wildlife Health Divisioin, Ottawa, ON, CANADA. **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, not 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, in conjunction with literature values, 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 well as a discussion of the uncertainties associated with the derivation of the TRVs will be addressed. *Keywords: Environmental contaminants, Wildlife, Polybrominated diphenyl ethers, Mink, Risk assessment.*

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. NEW Water, the brand of the Green Bay Metropolitan Sewerage District, is leading the project to evaluate if it is more cost effective to spend $200 million or more on wastewater treatment plant phosphorus improvements or to work with agriculture to reduce the amount of phosphorus reaching 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 is complete and being used to develop enhanced nutrient management plans and conservation plans that define management, operational, and structural measures to aid implementation of BMPs that reduce phosphorus and total suspended solids in Silver Creek. 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: Management, Water quality, Watersheds.*

SNIDER, D.M., HIRIART-BAER, V., and MILNE, J.E., Environment and Climate Change Canada, Canada Centre for Inland Waters, 867 Lakeshore Road, P.O. Box 5050, Burlington, ON, L7S 1A1, CANADA. **Causes & Consequences of Hypolimnetic Oxygen Depletion in Georgian Bay Embayments (Honey Harbour).**

North Bay and South Bay are two embayments of Georgian Bay (Lake Huron) located near the small community of Honey Harbour, ON. This area is densely populated with seasonal and permanent residences, and it is a popular destination for recreational boaters. Three years of intensive monitoring and research, prompted by concerns about degrading water quality, has revealed several basins that experience summer and fall hypoxia in the hypolimnion. This oxygen decline coincided with an accumulation of phosphorus and trace metals in the bottom-waters. This presentation will summarize our findings and investigate the causes and consequences of hypolimnetic oxygen depletion in the different basins using volume-weighted calculations. *Keywords: Phosphorus, Biogeochemistry, Georgian Bay, Watershed, Oxygen.*

SOULIGNAC, F.[1], DANIS, P.A.[2], BOUFFARD, D.[3], CHANUDET, V.[4], DAMBRINE, E.[5], GUENAND, Y.[6], GUILLERMIN, B.[1], HARMEL, T.[7], IBELINGS, B.[8], KIEFER, I.[3], TREVISAN, D.[1], UITTENBOGAARD, R.[9], and ANNEVILLE, O.[1], [1]French National Institute for Agricultural Research (INRA), Thonon-les-Bains, FRANCE; [2]French National Agency for Water and Aquatic Environments (ONEMA), Aix-en-Provence, FRANCE; [3]Ecole Polytechnique Fédérale de Lausanne (EPFL), Lausanne, SWITZERLAND; [4]Hydro Engineering Center of Electricité de France (EDF CIH), Le Bourget-du-Lac, FRANCE; [5]University Savoie Mont-Blanc, Chambéry, FRANCE; [6]SEGULA Technologies, Poisy, FRANCE; [7]Villefranche-sur-mer oceanological observatory, Villefranche-sur-mer, FRANCE; [8]University of Geneva, Geneva, SWITZERLAND; [9]Deltares, Delft, NETHERLANDS. **Using 3D modelling for understanding spatio-temporal heterogeneities of phytoplankton abundance.**

According to the European Water Framework Directive, water quality assessment is based on biological and physico-chemical parameters sampled at a unique station. However, in large lakes, these parameters exhibit important spatio-temporal heterogeneities. Understanding the dynamics of these heterogeneities and to what extent they alter the water quality assessment is essential prerequisites for objectively evaluating, protecting and restoring freshwater ecosystems. We analysed spatio-temporal variability of phytoplankton abundance in Lake Geneva (France/Switzerland) using MERIS satellite from 2002 to 2012 and used outputs of a 3D hydrodynamic model (Delft3D) to explain mechanisms responsible for the occurrence of hot-spot of phytoplankton abundance. In spring, chlorophyll-a horizontal heterogeneity occurs because of an earlier onset of phytoplankton growth in some littoral area. Spatial differences in the timing of phytoplankton growth can be explained by spatial variability in thermal stratification dynamics and nutrient inputs from river. In summer, spatial heterogeneity presents transient dynamics and is characterized by local higher phytoplankton abundances in relation to the impact of basin-scale upwellings. Using the 3D model, we highlighted the influence of hydrodynamics on the phenology and abundance of phytoplankton. *Keywords: Hydrodynamic model, Spatio-temporal heterogeneity, Ecosystem modeling, Chlorophyll-a, Remote sensing, Lake Geneva.*

SOWA, S.P.[1], WEIS, S.[1], KHOURY, M.[1], CARTER, S.[1], DATTA, A.[1], YACOBSON, E.[1], COLE, S.J.[2], and MOLNAR, S.[2], [1]The Nature Conservancy Michigan Chapter, 101 East Grand River Ave, Lansing, MI, 48906, USA; [2]Great Lakes Commission, 2805 S. Industrial Hwy Suite 100, Ann Arbor, MI, 48104, USA. **Great Lakes Inform: an online platform specifically designed to support landscape scale collaboration.**

Conservation across the Great Lakes requires unprecedented collaboration among scientists, resource managers and administrators, business leaders, and policy makers. But how can thousands of people collaborate efficiently over such a large geography. Great Lakes Inform (www.greatlakesinform.org) is an online platform specifically designed to

support independent, landscape-scale, collaboration. It serves as a "first stop" platform built to complement the many other valuable existing online data and information platforms. The Great Lakes Inform platform and support team together provide a suite of information management and delivery services to collaboratives to help them more efficiently achieve their goals and objectives. These services allow members of the collaboratives to focus on executing their strategies to maintain or restore the health of the Great Lakes rather than worry about the management and delivery of data and information. Recently, the Great Lakes Commission (GLC) and The Nature Conservancy (TNC) entered into a partnership to develop an online information management system to support the Blue Accounting Initiative. This new online platform will integrate GLC's well-established Great Lakes Information Network (www.great-lakes.net) and Great Lakes Inform. *Keywords: Collaboration, Monitoring, Information Delivery, Conservation, Great Lakes basin.*

SOWA, S.P.[1], KEITZER, S.C.[2], LUDSIN, S.A.[2], ANNIS, G.[2], DAGGUPATI, P.[3], FROEHLICH, A.M.[4], HERBERT, M.E.[1], JOHNSON, M.V.[5], YEN, H.[6], WHITE, M.J.[7], ARNOLD, J.G.[7], SASSON, A.M.[4], and REWA, C.A.[8], [1]The Nature Conservancy Michigan Chapter, 101 East Grand River Ave, Lansing, MI, 48906, USA; [2]The Ohio State University, 1314 Kinnear Road, Columbus, OH, 43212, USA; [3]Texas A&M University, 221B Spatial Science Laboratory 1500 Research Plaza, College Station, TX, 77943, USA; [4]The Nature Conservancy Ohio Chapter, 6375 Riverside Drive Suite 100, Dublin, OH, 43017, USA; [5]USDA-NRCS Soil Science and Resource Assessment Division, 720 East Blackland Rd, Temple, TX, 76502, USA; [6]Texas A&M Blackland Research and Extension Center, 720 East Blackland Rd, Temple, TX, 76502, USA; [7]USDA-ARS Grassland Soils and Water Research Laboratory, 808 East Blackland Road, Temple, TX, 76502, USA; [8]USDA-NRCS Resource Assessment Division, 6501 Sunnyside Ave, Beltsville, MD, 20705, USA. **Thinking outside the lake: How might Lake Erie nutrient management efforts benefit streams?**

Investment in agricultural conservation practices (CPs) to address Lake Erie re-eutrophication should offer benefits that extend beyond the lake. However, if such conditions are not explicitly considered in Lake Erie nutrient management strategies, this opportunity might be missed. We quantified the potential for CPs used to meet nutrient management goals for Lake Erie to simultaneously improve stream biological conditions throughout the western Lake Erie basin(WLEB) watershed. Our modeling simulations showed that widespread implementation of CPs would substantially reduce spring/early summer total phosphorus and dissolved reactive phosphorus (DRP) loads into Lake Erie from the WLEB watershed. Widespread CP implementation would also improve potential fish community health in >17,000 km of streams and reduce the percentage of streams in poor biological condition from 17% to 3%. Despite these improvements, we also found that even with widespread implementation of CPs, not all water quality goals would likely be met

for Lake Erie and degraded conditions would likely persist in many streams. Thus, while CPs can play an important role in in reducing Lake Erie re-eutrophication,additional strategies and emerging technologies appear necessary to help meet desired water quality conditions for the WLEB. *Keywords: Fish, Agriculture, Water quality, Nonpoint source pollution, Ecosystem modeling.*

SOWA, S.P.[1], KARPOVICH, D.[2], DEPINTO, J.V.[3], ANNIS, G.[1], BOLES, C.[3], FALES, M.[1], JOLDERSMA, B.[4], PEARSALL, D.R.[1], ROSS, J.[1], RUCINSKI, D.K.[3], SCHLEA, D.A.[3], VERHAMME, E.M.[3], ANDERSON, V.[5], BARTHOLIC, J.[5], and O'NEIL, G.[5], [1]The Nature Conservancy, 101 East Grand River Ave, Lansing, MI, 48906, USA; [2]Saginaw Valley State University, 7400 Bay Road, University Center, MI, 48710, USA; [3]LimnoTech, 501 Avis Drive, Ann Arbor, MI, 48108, USA; [4]Michigan Department of Environmental Quality, 525 West Allegan Street, P.O. Box 30473, Lansing, MI, 48909, USA; [5]Michigan State University Institute of Water Research, 101A Manly Miles Building 1405 S. Harrison Road, East Lansing, MI, 48823, USA. **Optimizing management actions to benefit multiple ecological & socioeconomic factors in Saginaw Bay.**

Over the past several decades there have been major investments in the development of information, models, and decision tools to support effective ecological restoration of Saginaw Bay and its watershed. However, none of these efforts have been able to explicitly link conservation actions within the watershed to valued ecological and socioeconomic features of the Bay. This presentation will provide an overview of the development and application of the Saginaw Bay Optimization Decision Model (ODM) toolkit. The ODM toolkit was developed through an integration of existing watershed and bay models and decision tools that allowed us to quantify the marginal influence of individual catchments on specific locations within Saginaw Bay. This new innovative modeling capability of the ODM allowed us to conduct optimization analyses to inform future restoration efforts by prioritizing the placement of agricultural best management practices to achieve multiple ecological and socioeconomic benefits within Saginaw Bay. The ODM toolkit also allowed us to perform retrospective analyses of past restoration efforts to assess the effectiveness and efficiency of these programs. *Keywords: Assessments, Agricutlure, Conservation, Ecosystem services, Spatial analysis.*

SPIESE, C.E., BOWLING, M.N., PINKNEY, A.L., MOELLER, S., BOISE, A., and WILSON, H.J., Ohio Northern University, Ada, OH, 45810, USA. **Phosphate Desorption by Glyphosate in the Maumee River Watershed: Implications for Western Lake Erie.**

The western Lake Erie basin has been experiencing increased dissolved phosphorus loads over the last ~20 years. The underlying causes are at best poorly defined and poorly understood. Because of the tight coupling of the land to the Lake, changing agricultural practices are almost certain to have a measurable effect on SRP loads in the tributaries and thus the Lake itself. These practices include some of the BMPs such as no-till agriculture and cover crops. With no-till practices, however, comes the need for alternative weed control, often in the form of glyphosate. Glyphosate the most commonly used herbicide in the nation, including in no-till agriculture. As a phosphonate, glyphosate is known to bind strongly to metal cations, as well as to soil surfaces. Previous studies have found that while phosphate binds more strongly, glyphosate is able to displace phosphate from various mineral surfaces to varying degrees. Using native soils in the Maumee River watershed, we demonstrate the capacity for glyphosate to displace phosphate. The underlying physical chemistry is also explored, suggesting factors that increase desorption potential of soils. *Keywords: Glyphosate, Soils, Nutrients.*

ST.PIERRE, K.A.[1], ST.LOUIS, V.L.[1], LEHNHERR, I.[2], AUKES, P.[3], SCHIFF, S.L.[3], MUIR, D.C.G.[4], and TALBOT, C.[4], [1]University of Alberta, Edmonton, AB, CANADA; [2]University of Toronto Mississauga, Mississauga, ON, CANADA; [3]University of Waterloo, Waterloo, ON, CANADA; [4]Canada Centre for Inland Waters, Burlington, ON, CANADA. **Source or Sink?: Climate Change Impacts on CO2 and Hg Cycling in High Arctic Lake Hazen.**

Polar landscapes are transforming at unprecedented rates in response to recent climate change: growing seasons are lengthening, permafrost is thawing and glaciers are melting. These meltwaters are sources of nutrients and pollutants and are draining into the region's rivers and lakes. Lake Hazen is the world's largest high arctic lake (540 km^2, 81°N). Its 8400 km^2 watershed is a third glaciated and underlain by permafrost, making the watershed particularly sensitive to climate change. Since 2005, glacial run-off into the lake has increased 10 fold, mirrored by sedimentation. However, the impact of these meltwaters on the structure, productivity and water quality of Lake Hazen has yet to be determined. In 2014 and 2015, we conducted a detailed survey of key chemical (nutrients, contaminants) and physical parameters throughout the Lake Hazen watershed, including glacial rivers, permafrost thaw streams, snowmelt and the 267 m watercolumn. Complete summer turnover of the watercolumn is entirely driven by glacier-fed turbidity currents with important implications for oxygenation of the bottom waters. Consequences of climate change on greenhouse gas dynamics and contaminants will be emphasized. Results from 2014 and 2015 as well as future directions will be discussed. *Keywords: Biogeochemistry, Carbon cycle, Watersheds.*

STADIG, E.R.[1], HENSLER, S.R.[2], GILLESPIE, R.B.[1], and DEMOTT, W.R.[1], [1]Purdue University (Fort Wayne), Fort Wayne, IN, USA; [2]U.S. Fish and Wildlife Service, Alpena Fish & Wildlife Conservation Office, Alpena, MI, USA. **Optimizing Trap Design for Capture of Amphipods in western Lake Erie.**

Comprehensive early detection monitoring programs for aquatic invasive fishes, bivalves & select benthic macroinvertebrates are currently being conducted throughout the Laurentian Great Lakes. To improve the sampling efficiency of survey efforts, we evaluated three amphipod trap designs. These included two novel designs and one previously published design set in four treatment configurations (light, bait, light & bait combined, and no stimulus). By examining two experimental designs, our objectives were to determine if any trap or treatment cue could improve capture efficiencies (via CPUE). Sampling took place with collaboration from U.S. Fish and Wildlife during their 2015 Ichthyoplankton surveys within Maumee Bay of western Lake Erie. Preliminary results indicate that using light sources (100+ lumens) within certain traps may significantly increase CPUE of amphipods ($\alpha=0.05$; p-values= <0.05 to <0.0001). Additionally, results indicate that certain treatments may promote species specific methods for capture of native and non-native species (*Gammarus fasciatus* and *Echinogammarus ischnus*, respectively). These results may help researchers optimize efforts to assess amphipods assemblages and monitoring for potential high-risk invasive amphipod species. *Keywords: Amphipods, Lake Erie, Monitoring.*

STAINSBY, E.A.[1] and PATERSON, A.M.[2], [1]Environmental Monitoring & Reporting Branch, Ontario Ministry of the Environment & Climate Change, 125 Resources Road, Etobicoke, ON, M9P 3V6, CANADA; [2]Dorset Environmental Science Centre, Ontario Ministry of the Environment & Climate Change, 1026 Bellwood Acres Road, Dorset, ON, P0A 1E0, CANADA. **Ontario's Lakeshore Capacity Assessment: Drafting a New Approach.**

Lakeshore Capacity Assessment is a planning tool that can be used to predict the level of development that can be sustained along the shoreline of an inland lake without causing adverse effects to water quality, deepwater dissolved oxygen concentrations, or its aesthetic condition. The Lakeshore Capacity Assessment Handbook is the current guidance document for Lakeshore Capacity Assessment in Ontario. It provides a resource to municipalities and other planning authorities regarding the management of shoreline development on inland lakes within the Precambrian Shield. The Handbook was designed to promote land-use decisions that maintain or enhance water quality, and to encourage a clear, coordinated and scientifically sound approach that reduces conflict among stakeholders. While the Handbook has provided a consistent and coordinated approach, it has presented frontline staff with challenges as new science and technology has developed. Considering

emergence science, and with a commitment to enhance the effectiveness of the handbook, the province is exploring updates to its current approach to lakeshore management.
Keywords: Lake management, Land use planning, Environmental policy, Water quality.

STANG, C., GHARABAGHI, B., RUDRA, R.P., GOLMOHAMMADI, G., and MAHBOUBI, A.A., University of Guelph, 50 Stone Road East, Guelph, ON, N1G 2W1, CANADA. **Evaluation of Agricultural Management Practices for Protection of the Great Lakes Water Quality.**

The success of implementation of extensive agricultural management practices for reduction of the nutrient loads from the Hog Creek and Sturgeon River watersheds to the Great Lakes were investigated using two decades of water quality monitoring data from pre-implementation to post-implementation period. Conservation management programs successfully achieved 49% reduction in sediment loads for the Hog Creek and 41% reduction for the Sturgeon River. The most widely adopted management practice that greatly influenced the overall removal in sediment loads were stream bank fencing, no-till farming and vegetative buffer strips. This study recommends extensive implementation of these promising practices for identified Areas of Concern on the Great Lakes. The long-term water quality improvement benefits of conservation management practices, can be an integral part of an adaptive management strategy for agricultural watersheds. *Keywords: Water quality, Agricultural, Watersheds, Best Management Practices, Modeling.*

STANISLAWCZYK, K., JOHANSSON, M.L., and MACISAAC, H.J., University of Windsor, 401 Sunset Ave, Windsor, ON, N9B 3P4, CANADA. **Comparison of traditional and novel techniques for detecting and identifying rare zooplankton.**

Aquatic invasive species (AIS), including zebra mussel, and fishhook waterflea, have negatively impacted ecosystems since their introduction. Many of these AIS were introduced and moved via ballast water. When a species is first introduced, its population size will generally be small. This is the best time to eradicate AIS; however, it is also when detection is most difficult. We hypothesize that rare species will be more easily found as they become more abundant, or when sampling effort is increased. In addition, more conspicuous species, those morphologically different than the native fauna, are more likely to be detected. We spiked different densities of Cladocera species never reported in Lake Ontario into zooplankton samples collected from Hamilton Harbour, to simulate rarity and assess detection rate when using taxonomy versus FlowCAM technologies. Additionally, water samples from Hamilton Harbour will be analyzed using these techniques to discover rarity in situ. We postulate that the FlowCAM will be able to process a larger amount of data, but

that morphologically similar taxa will be distinguished more readily with taxonomy. This study provides tools to monitor rare aquatic species as well as a means to combat AIS at the frontiers of invasion and provides a way to further test hypotheses of establishment and invasion. *Keywords: Early Detection, FlowCAM, Hamilton Harbour.*

STAPLES, J.[1] and OLINSKI, S.[2], [1]Ministry of Natural Resources and Forestry, Peterborough, CANADA; [2]Ministry of Environment and Climate Change, 125 Resources Road East Wing, Toronto, CANADA. **Reporting Ontario's Water Use under the Great Lakes-St. Lawrence River Basin Sustainable Water Resources Agreement.**

Under the terms of the Great Lakes-St. Lawrence River Basin Sustainable Water Resources Agreement, states and provinces within the basin annually submit aggregated water use data to a regional water use database. This information is used to support an improved scientific understanding of the impact of water withdrawals on the Basin ecosystem. In Ontario, an internet based reporting system allows permit holders to submit their water taking data electronically. This presentation will describe an interim methodology recently developed and tested that incorporates the aggregated data and related consumption coefficients into regional data submissions under the Agreement. These advancements were designed to support improved regional estimates and reporting of water withdrawals and consumption for scientific purposes. *Keywords: Great Lakes basin, Water use reporting.*

STEFANOFF, S.[1], VOGT, R.[2], HOWELL, E.T.[3], and SHARMA, S.[1], [1]YORK UNIVERSITY, Toronto, CANADA; [2]TRENT UNIVERSITY, Peterborough, ON, CANADA; [3]ONTARIO MINISTRY OF THE ENVIRONMENT AND CLIMATE CHANGE, Toronto, ON, CANADA. **Examining the Drivers of Primary Production Patterns Along the South-East Shoreline of Lake Huron.**

Observed increases in the occurrence of shoreline fouling by algae in the southeast region of Lake Huron have been attributed to changes in surrounding land use and to the invasion of Dreissenid mussels. Water chemistry, algal and Dreissenid cover data were collected by the Ontario Ministry of Environment and Climate Change along the shoreline of Lake Huron for the Inverhuron and Point Clark regions. We developed multiple regression models and used a variation partitioning framework to quantify the variation in chlorophyll *a* concentrations and *Cladophora* biomass/cover explained by land use, water chemistry, invasive species, and spatial patterns. Our results suggest that total phosphorus is the most important predictor of chlorophyll *a*, explaining between 62-99% of variation, with both nutrient and chlorophyll concentrations displaying spatial structure at the mouths of tributaries and in close proximity to development along the shoreline. In addition, 13-47% of *Cladophora* biomass/cover was explained by invasive Dreissenid mussels. Our study provides evidence for the "nearshore shunt hypothesis", as patterns in algal biomass in the nearshore of this oligotrophic system are structured by the redirection of nutrients to the benthic zone, and highlights the drivers in this multi-stressor system. *Keywords: Lake Huron, Algae, Invasive species.*

STEPIEN, C.A., NINER, M.D., PIERCE, L.R., and EDWARDS, S.A., University of Toledo Lake Erie Center, 6200 Bayshore Rd., Toledo, Oh, 43616, USA. **Genetic History of the VHS Fish Virus' Decade in our Great Lakes: Still Here and Mutating!.**

Viral Hemorrhagic Septicemia virus (VHSv) causes one of the world's most serious fish diseases, infecting >80 freshwater and marine species. A new, novel, and especially virulent substrain -VHSv-IVb- first appeared in the Laurentian Great Lakes about a decade ago, resulting in massive fish kills of >30 species. It rapidly spread and has extensively genetically diversified. We analyze its mutational patterns across its decade of occurrence in the Great Lakes, including new 2015 isolates discovered in round goby and white perch from central Lake Erie, and unique variants from drum and largemouth bass in central Lake Erie, which lacked classic VHS symptoms. Patterns of evolutionary changes coincided among VHSv genes for some of the isolates, but appear independent in others. New viral variants were discerned following the large 2006 outbreak; such differentiation may have been in response to fish populations developing resistance. Rapid evolutionary diversification may allow new viral variants to evade fish host recognition and immune responses, facilitating long-time persistence along with expansion to new geographic areas. *Keywords: Fish diseases, Fish management, Genetics, VHS, Fish populations, Virus.*

STEVACK, K.M.[1], SIBLEY, P.[1], and POIRIER, D.G.[2], [1]University of Guelph, 50 Stone Rd E, Guelph, ON, N1G2W1, CANADA; [2]Ontario Ministry of Environment and Climate Change, 125 Resources Rd, Toronto, ON, M9P3V6, CANADA. **Assessing Historical and Emergent Sediment Contamination in Three Lake Ontario Areas of Concern.**

Contaminated sediment has been identified as one of the major impediments to the restoration of many Areas of Concern (AOCs) in the Great Lakes. In this study, we evaluated two Lake Ontario AOCs (Metro Toronto Harbour region (TO), and Hamilton Harbour (HH)) both of which present unique beneficial use impairments (BUI) related to sources and type of sediment contamination, and which have unique Remedial Action Plans geared towards BUI improvement. We wanted to determine if improvements have occurred relative to reference and historical conditions. Sediment contamination in these AOCs was assessed using a sediment quality tetrad (SQTet) that included bulk sediment chemistry, toxicity testing, benthic community analysis, and bioaccumulation potential. Results show continued concern surrounding PAHs in TO and HH sediments, with at least one site exceeding the severe effect level (SEL) for Provincial Sediment Quality Guidelines in TO, and all three exceeding the SEL in HH. PCBs also continue to be a concern in some areas of HH. Sediments from HH resulted in growth and reproductive impairments in life-cycle exposures using the amphipod Hyalella azteca and the midge Chironomus dilutus. The results indicate that sediment contamination at the two AOCs remains high, and suggest delisting is not imminent. *Keywords: Benthos, Areas of Concern, Environmental contaminants, Toronto Harbour, Hamilton Harbour.*

STILLE, J.F.B.[1] and TONINGER, R.[2], [1]Toronto and Region Conservation, 5 Shoreham Drive, Toronto, ON, M3N 1S4, CANADA; [2]Toronto and Region Conservation, 5 Shoreham Drive, Toronto, ON, M3N 1S4, CANADA. **Integrated Restoration Prioritization using Long Term Monitoing and Modelling Data.**

Toronto and Region Conservation and partners have developed a multi-discipline and multi-benefit approach to restoration prioritization to enable restoration outcomes that help to realize the requirements of our funding partners, TRCA's watershed objectives, and development compensation options. Ecosystem restoration planning requires an integrated approach, considering many components of the natural system when prioritizing where and what to restore. Through different long term monitoring and modeling initiatives TRCA has amassed a wealth of knowledge on terrestrial biodiversity, aquatic ecosystems, surface and ground water, and headwater streams. The process involves consolidating data and comparing discreet areas based on different parameters and thresholds that can help direct decision making for future restoration initiatives. The goal is to identify impairments and threats to ecosystem function as a means to improve the delivery ecological goods and services. Challenges include determining relevant and usable information that can be applied consistently at a regional scale. The first iteration of the Integrated Restoration Prioritization process analyzed existing datasets, identified data gaps, and made recommendations for future monitoring. *Keywords: Regional analysis, Restoration, Watersheds, Prioritization, Ecosystems.*

STONE, M.[1], EMELKO, M.B.[1], SILINS, U.[2], COLLINS, A.[3], WILLIAMS, C.[2], MARTENS, A.[2], and BLADON, K.[4], [1]University of Waterloo, Waterloo, CANADA; [2]University of Alberta, Edmonton, AB, CANADA; [3]Rothamsted Research, North Wyke, Okehampton, ENGLAND; [4]Oregon state University, Corvalis, USA. **Impact of wildfire on phosphorus speciation and sorption behavior of sediment in Alberta rivers.**

Large scale landscape disturbance by wildfire can alter water quality in streams. We report long term changes in sediment and phosphorus (P) production, P speciation and sorption behavior of sediment and its impact on algae in streams studied for 10 years after severe wildfire in forested headwaters of the Oldman River Basin, Alberta. Seven watersheds with varying levels of disturbance (burned, post-fire salvage logged, unburned) were monitored. Discharge and changes in concentrations and yields of sediment and phosphorus (TP, SRP) are quantified. The spatial distribution of PP forms (NAIP, AP, OP) and phosphorus sorption characteristics (EPC0) of suspended sediment are characterized to evaluate both the downstream propagation and longevity of wildfire effects on these parameters across a range of watersheds scales, up to the large river basin scale. Levels of the most bioavailable particulate P form (NAIP) were significantly higher in burned and post-fire salvage logged streams compared to reference streams. The measured EPC0 associated with sediments collected from burned and post-fire salvage logged tributaries were significantly higher than solids from reference streams. Coupled P and sediment interactions lead to slow recovery of P regimes in fire-disturbed watersheds. *Keywords: Phosphorus, Speciation, Sediment quality, Sorption, Water quality, Bioavailbility.*

STOTT, W.[1] and YULE, D.L.[2], [1]Great Lakes Science Center-USGS, 1451 Green Rd., Ann Arbor, MI, 48105, USA; [2]Lake Superior Biological Station-USGS, 2800 Lake Shore Dr., E. Ashland, WI, 54806, USA. **Genetic Diversity Among Great Lakes Cisco Species: Exploring Taxonomic and Population Boundaries.**

Ciscoes (*Coregonus artedi, hoyi, kiyi*, and *zenithicus*) once formed a diverse species flock that was an important part of the Great Lakes food web. Now the deepwater forms of cisco are most abundant in Lake Superior, bloater and cisco are observed in lakes Huron and Michigan, and only cisco are observed in Lake Ontario. Prior to their collapse, there were questions about the taxonomic status and population structure of the species flock that were never completely resolved. Recent changes to the community structure of lakes Michigan and Huron has generated interest in restoring a native fish community to promote healthy ecological function of the food web. Understanding the population structure of current populations is necessary to inform management actions that involved establishment and use of stocking of hatchery fish. To this end, mitochondrial and nuclear DNA diversity was assessed in a collection of contemporary ciscoes from the Great Lakes to determine levels of diversity and population structure of the remaining populations. Microsatellite DNA variation indicated that there were differences among species. There were also differences in levels of observed population structure between bloater and cisco. *Keywords: Fish populations, Genetics.*

STOW, C.A.[1], QIAN, S.S.[2], DAVIS, T.W.[1], GOSSIAUX, D.[1], JOHENGEN, T.H.[3], BURTNER, A.[3], PALLADINO, D.[3], and RITZENTHALER, A.[3], [1]NOAA-GLERL, Ann

Arbor, MI, 48108, USA; [2]The University of Toledo, 2801 W. Bancroft Street, Toledo, OH, 43606, USA; [3]University of Michigan-CILER, 4840 South State Road, Ann Arbor, MI, 48108, USA. **Exploratory Data Analysis on Factors Related to Microcystin Concentration in Western Lake Erie.**

Environmental factors affecting the production of the cyanobacterial toxins, microcystins, are explored using a large data set to support developing strategies for controlling and mitigating harmful algal bloom growth and toxicity. Although nutrient oversupply, both nitrogen and phosphorus, are the consensus root cause of harmful algal blooms, factors affecting the production of cyanotoxins are less understood. Using a large data set collected by NOAA-GLERL/CILER, we analyze the potential factors associated with the variation of microcystins concentrations in western Lake Erie with an aim of developing a predictive model. Our analysis suggests that concentrations of microcystins are negatively correlated with N:P ratio. However, total nutrient level is a more important factor over a large spatial scale. In the western basin of Lake Erie, our analysis leads to a more detailed model, in which, phosphorus is the main factor in developing algal blooms, which in turn creates the necessary condition for the production of microcystins. When phytoplankton biomass (measured by particulate organic carbon) is high (in late summer and early fall), concentrations of microcystins are strongly correlated with nitrogen concentrations. *Keywords: Cyanophyta, Monitoring, Data acquisition, Modeling.*

STRANGWAY, C.[1], BOWMAN, M.F.[2], and KIRKWOOD, A.E.[1], [1]University of Ontario Institute of Technology, 2000 Simcoe St.N., Oshawa, ON, L1H7K4, CANADA; [2]Forensecology, 70 Swift Cres., Guelph, ON, N1E7J1, CANADA. **Assessment of Land-use Impacts on Water Quality and Phytoplankton Communities in the Vermilion River.**

The Vermilion River and major tributaries (VRMT) receive point and non-point inputs, in addition to flow regulation features, along their continuum. Further development in the VRMT has raised concerns about cumulative impacts to ecosystem health. To assess the current state of riverine health, water quality and phytoplankton were monitored monthly at 28 sites during the ice-free period (2013-2014). Landscape-scale data revealed a broad range of quaternary geology, land-cover, and road densities in the watershed. Impervious land-cover types (i.e. barren and developed land-cover) and road density were positively correlated with many water quality variables (e.g., chloride, nitrate) whereas forest cover was negatively correlated (e.g., pH, chloride, nitrate). Sites on the Junction tributary had the highest average values for the majority of water quality variables measured. Sites located downstream of the Sudbury WWTP were particularly distinct, having above average values for chlorophyll-a, total phosphorus, nitrate, and nitrite. The abundance and

composition of phytoplankton taxa were also distinct among sites, further highlighting a land-use gradient. Cumulative impacts from the surrounding landscape, in conjunction with upstream inputs, should be considered before further development occurs in the Vermilion River watershed. *Keywords: Cumulative impacts, GIS, Land-use, Phytoplankton, Tributaries, Watersheds.*

STROPE, E.K., NEWELL, S.E., MYERS, J.A., and MCCARTHY, M.J., Wright State University, 3640 Colonel Glenn Hwy., Dayton, OH, 45435, USA. **Nutrient sample collection methods: does pore size really matter?**

Excess nitrogen and phosphorus discharges into aquatic ecosystems have been linked to adverse effects on water quality, such as eutrophication. To measure nutrient concentrations in water samples, filtering is used to remove any organisms or organic material that could cause changes in the nutrient concentration of a sample. If the time between collecting and analyzing/freezing the sample and/or a filter with a larger pore size than the smallest organisms is used, nutrient measurements could be inaccurate due to biological activity occurring within the samples. An assessment of ammonium and orthophosphate concentrations at 24 freshwater sites was completed using three different filter sizes, 0.2 µm, 0.45 µm, and 0.7 µm, over a time period from immediate filtering in the field, filtering five hours after initial sample collection, and filtering 22 hours after initial sample collection. Preliminary results show potentially significant differences in ammonium and orthophosphate concentrations between using 0.2 µm filters and 0.7 µm filters. Also, filtering immediately in the field versus several hours later, under light and dark conditions, resulted in significant differences in measured concentrations. Current sampling protocols may require modifications to ensure accurate concentration measurements and data interpretation. *Keywords: Nutrients, Water quality, Algae.*

STRYCHAR, K.B. and LUTTENTON, M., Grand Valley State University, Allendale, MI, 49401, USA. **Early detection of cercarial dermatitis (swimmer's itch) and its relationship between particular nut.**

Cercarial dermatitis (swimmer's itch) ranges from New England to Western Canada, and south to New Mexico, including the Laurentian Great Lakes. In Michigan, cercarial dermatitis occurs in both the Great Lakes and in inland lakes and efforts to control swimmers itch have not been successful; thus, swimmer's itch continues to plague this region during summer recreational periods. Outbreaks of swimmer's itch in Higgins Lake, MI (United States), a popular summer destination, have drawn attention to the issue and the need to understand factors driving parasite abundance and the need for methods to detect cercariae abundance. To that end, we found a strong correlation between chlorophyll a, snail densities and the number of snails infected with the parasite. We also evaluated the potential of using imaging flow cytometry as an early detection tool to determine the abundance of cercariae that cause swimmer's itch. Preliminary analysis indicates that imaging flow cytometry can distinguish between cercaria that cause cercarial dermatitis and those that do not. *Keywords: Cercarial dermatitis, Swimmer's itch, Snails.*

STUART, D.G.[1], PALLADINO, D.[1], JOHENGEN, T.H.[1], RUBERG, S.A.[2], PURCELL, H.L.[1], MILLER, R.J.[1], ANDERSON, E.J.[2], VANDER WOUDE, A.J.[1], BURTNER, A.[1], SMITH, J.P.[1], and DAVIS, T.W.[2], [1]Cooperative Institute for Limnology Ecosystems Research (CILER), 440 Church St, Ann Arbor, MI, 48109, USA; [2]NOAA-GLERL, 4840 S State Rd, Ann Arbor, MI, 48108, USA. **Improvements in Monitoring and Prediction of Western Lake Erie Harmful Algal Blooms.**

The factors contributing to harmful algal bloom (HAB) initiation and persistence are not well understood in western Lake Erie. HAB detection and prediction have improved annually through incorporation of additional weekly monitoring stations and samples, continuous/real-time data buoys at four locations, hyperspectral imaging and innovative modeling programs. Hyperspectral data were utilized for algorithm-based, remote sensing predictions of chlorophyll a and phycocyanin concentrations. The combination of real-time observations with nutrient and cyanobacterial data from monitoring sites provides input for generating models of bloom development. The HAB Tracker is an experimental information portal with a particle model incorporating satellite imagery and water currents to show probable bloom progression. Five-day forecasts of bloom intensity and distribution were provided to guide testing and treatment efforts by local governments. Weekly toxicity results and measurements of vertical distributions of blooms were released to dozens of users and the public to aid with decisions about water intake. The 2016 season will see the continued weekly monitoring, incorporation of an autonomous environmental sample processor at a fixed station as well as increased hyperspectral data collection. *Keywords: Model studies, Harmful algal blooms, Water quality.*

SU, G.[1], GREAVES, A.K.[2], and LETCHER, R.J.[1], [1]Environment and Climate Change Canada, Ottawa, ON, K1S 5B6, CANADA; [2]Carleton University, Ottawa, ON, K1S 5B6, CANADA. **In Vitro Metabolism of the Flame Retardant SAYTEX120 and Breakdown Products Using Microsomal Assays.**

The metabolism of tetradecabromo-1,4-diphenoxybenzene (TeDB-DiPhOBz) and photodegraded PB-DiPhOBz products was investigated using an in vitro assay based on liver microsomes of herring gull and adult male Wister-Han rat. TeDB-DiPhOBz was

dissolved in 30 % THF/n-hexane solution (300 μM) and irradiated over time by natural sunlight and subsequently by UV. Four time-point fractions were collected where Fractions 1-4 were dominated by TeDB-DiPhOBz, Br_{8-11}-, Br_{5-8}-, and Br_{4-6}-PB-DiPhOBzs, respectively. In the gull microsomal assay incubated over 90 min., there was no depletion of TeDB-DiPhOBz in Fraction 1 or the Br_{8-11}-PB-DiPhOBzs in Fraction 2, which suggested that within the assay time frame the metabolism was simply too slow to measure. However, for Fraction 3, in the gull assay one OH-Br4-PB-DiPhOBz and one OH-Br3-PB-DiPhOBz metabolite formed, and for Fraction 4 two OH-Br4-PB-DiPhOBz metabolites formed. In addition, Fraction 2, 3 and 4 incubation with the gull microsomes generated three OH-Br2-polyfuran and three OH-Br3-polyfuran metabolites. These findings indicate that herring gulls are capable of metabolizing the photolytic PB-DiPhOBz products to OH-PB-DiPhOBz metabolites, which are the ultimate precursors to MeO-PB-DiPhOBz contaminants previously reported in herring gulls. *Keywords: Metabolism, Flame Retardants, Great Lakes basin, Mass spectrometry.*

SUTHERLAND, B.R.[1], SNOW, K.[2], KNUDSON, C.[1], and GINGRAS, M.K.[1], [1]University of Alberta, Edmonton, AB, CANADA; [2]Australian National University, Canberra, AUSTRALIA. **Particle Transport in Stratified Lakes: Laboratory Experiments.**

Through laboratory experiments, the transport of particles by hypopycnal and hyperpycnal currents flowing into an idealized stratified lake is examined. The transport down a slope of particles from hyperpycnal (turbidity) currents is shown to separate from the bottom in a stratified fluid. Even for hypopycnal currents (with particle density so small that they ride initially over the surface), experiments show that the particles that settle through uniform-density fluid toward a sloping bottom eventually form a turbidity current and so transport the particles further downslope from where the hypopycnal current stops. Some of the particles from this current eventually rise again. The settling of particles from a hypopycnal current through a stratified lake is also examined and the settled particle distribution measured. *Keywords: Sediment transport, Mathematical models, Turbidity.*

SWEENEY, S.J.[1], SCRIVER, R.[1], PETTES, S.[1], and DZINIC, O.[2], [1]Ontario Ministry of Agriculture and Food and Ministry of Rural Affairs, 1 Stone Road West, Guelph, ON, N1G 4Y2, CANADA; [2]University of Waterloo, Waterloo, ON, CANADA. **Agricultural landscapes of Ontario's Western Lake Erie Basin: Map product coverage for the past deca.**

Chronic algal fouling in the western basin of Lake Erie has been linked, at least in part, to farm management activities across the agricultural landscapes of the region. Farmers decide on and implement management practice options at the field-specific level. Systematic geospatial tracking of these can best be accomplished on a field-by-field basis. The Ontario Agricultural Resource Inventory (AgRI; Sweeney et al., 2013) is a high-resolution, digital polygon framework inclusive of all farm and rural landscape features within this region. It has been crafted using orthophotography products (at 30cm and 20cm pixel resolution), captured in both Spring 2006 and Spring 2010, for the Canadian portion of the Western Lake Erie Basin (WLEB). Currently, an Ontario AgRI version for the WLEB region is being crafted from Spring 2015 (20cm pixel resolution) orthophotography. These benchmarked Ontario AgRI polygon framework versions permit the past decade of the agricultural landscape story of the province's WLEB region to be told at the field-by-field level. Crop mapping results are presented for parts of this region for year-specific time intervals over this past decade. *Keywords: Agriculture, Landscape, Mapping.*

SZABO, J.L., FREELAND, J.R., DORKEN, M.E., and PIEPER, S.J., Trent University, 2140 East Bank Drive, peterborough, ON, K9J 7B8, CANADA. **Environmental factors can help explain the domination of wetlands by invasive hybrid cattails.**

In northeastern North America, native broadleaf cattail *T. latifolia* hybridize with introduced narrowleaf cattail *T.angustifolia* to form the invasive hybrid *T. x glauca*. One mechanism by which *T. x glauca* reduces wetland plant diversity is through the production of copious amounts of leaf litter, which decomposes and leaches into the water system while reducing available sunlight to germinating seeds and young seedlings. In the summer of 2015, we used a common garden experiment to test the effects of *T. x glauca* leaf litter on the hybrid plants and both parental species. Seeds from parents that had been identified to species from their genotypes were germinated, and young plants were transferred to 20 ponds that were randomized for four treatments: 50% shade, application of litter from *T. x glauca* stands, a combination of shade and litter, and a control (no shade or litter). We measured plant growth for six weeks and assessed final productivity from above-and-below ground biomass. The results provide insight into mechanisms that help invasive Typha hybrids to outcompete parental species and dominate wetlands in the eastern Great Lakes region. These results provide guidance for managers on the importance of clearing litter from wetlands that are increasingly dominated by hybrid cattails. *Keywords: Biological invasions, Wetlands, Environmental effects.*

T

TAN, C.S. and ZHANG, T.Q., AAFC, Research & Development Centre, RR#2, 2585 County Rd. 20, Harrow, ON, N0R 1G0, CANADA. **Drainage Control and Water Recycling to Reduce Nutrient Loadings to Great Lakes.**

There is a strong public demand for a safe and secure water supply. Non-point source pollutions from agricultural lands have become a big concern in the Great Lakes. Algal blooms have posed serious risks to drinking water supplies, ecosystems and the economy. A cost effective drainage water management & water recycling study was conducted in southern Ontario to improve water and nutrient management while protecting the environment and ensuring food safety and quality. The objectives of these studies were to determine the effectiveness of the innovative drainage water management systems for reducing nutrient loadings and improving crops performance. The control drainage/subirrigation (CDS)-reservoir water recycling system under no-till field crop production reduced total P and N losses by 12% and 21% relative to the regular free drainage (RFD) system, respectively. This system consistently increased corn and soybean yields relative to RFD system. The drainage control (CD) only system under no-till reduced total P and N losses by 25 % and 16 % compared to RFD. However, the CD system under conventional till reduced total P and N losses by 13% and 7 % relative to RFD, respectively. There was limited yield increase from CD system under both no-till and conventional tillage.
Keywords: Nutrients, Drainage control, Phosphorus, Water recycling, Water quality.

TANG, R.W.K., LEISTI, K.E., DOKA, S.E., LEWIN, A., MACEACHERN, J., and GERTZEN, E.L., Fisheries and Oceans Canada, 867 Lakeshore Rd, Burlington, ON, L7S 1A1, CANADA. **Bay of Quinte Long-Term Submerged Aquatic Vegetation Monitoring: A Modelling Approach.**

Submerged aquatic vegetation (SAV) is an important component for aquatic ecosystems that affects the physical and chemical nature of their local environment and provides spawning, nursery and adult habitat for numerous fish species. Bay of Quinte (BQ) Upper Bay Area of Concern (AOC) is a narrow bay located at the northern shore of Lake Ontario. Numerous studies have reported decline in SAV occurrence and abundance since the 1960s due to eutrophication. The Fish and Wildlife Habitat criteria include (FWH-1A) a SAV density component of meeting a 30% of total areal extent of dense SAV (50 - 100% cover) over the Upper BQ. We combined multiple historical SAV survey datasets ranging from 1972 to 2011 and developed a 2-step SAV model to hindcast the presence, extent and density of SAV in 2 different time stanzas over the 36 year period. In step-1, a logistic model was used to determine the maximum depth of SAV presence based on relationships with water clarity and depth. In step-2, SAV distribution and density were hindcasted using average growing season water depth for each grid cell and the seasonal mean water clarity. Predictions in the second time stanza indicates a substantial expansion of dense SAV beds from an initial 38.7km2 to 59.4km2, where it is 3.3% over the delisting target outlined in criteria FHW-1A. *Keywords: Bay of Quinte, Submerged plants, Modeling.*

TAYLOR, D.J. and WILLIAMS, I., Hiram College, PO Box 67, Biology Department, Hiram, OH, 44234, USA. **Addressing Community Water Issues with Adult and Adolescent Learners Through Service Learning.**

Improving water quality in the Great Lakes remains a problem nearly 50 years after passage of the Clean Water Act. In fact, many citizens of the Great Lake basin are unaware of their own impacts on local watersheds. Even if aware, they don't know how to proceed to bring about change. We report here on efforts to include individual service learning projects in high school courses in two formats: 1) where identifying water issues and constructing service learning projects became real planned academic work of the students for credit versus 2) service learning projects that were optional after school activities. We also report on university level courses where adult learners investigate local environments using biomonitoring protocols taught in the classes. Traditional tests are then replaced by a series of activities in which students identify local watershed issues in their own communities and then construct service-learning projects, civic environmentalism or citizen science programs to engage local students or adult citizens in finding solutions. The instrumental role undergraduate can play as mentors and stewardship liaisons will be discussed with examples from projects spanning ten years of action research on civic engagement.
Keywords: Watersheds, Urban watersheds, Environmental education.

TENTINGER, S.H.[1] and PENNUTO, C.M.[2], [1]Biology Department, Buffalo State College, 1300 Elmwood Avenue, Buffalo, NY, 14222, USA; [2]Great Lakes Center, Buffalo State College, 1300 Elmwood Avneue, Buffalo, NY, 14222, USA. **Does a New Benthic Predator Alter Leaf Litter Breakdown by Crayfish in a Heterotrophic Stream.**

Trophic cascades are powerful feeding interactions that can alter the flow of energy and the abundance of species in ecosystems. This is particularly true for autochthonous driven systems, but less is known for heterotrophic streams. In streams of Western New York, the round goby (*Neogobius melanostomus*) has altered the benthic community by consuming many of the macroinvertebrates that are important in breaking down CPOM to FPOM. However, no experiment has examined how round gobies, a generalist invertivore, might alter the role of a native crayfish (*Orconectes propinquus*), a generalist omnivore in the breakdown of leaf litter. I conducted a full factorial field enclosure experiment to determine if round gobies affected leaf litter decay by altering the role of the crayfish in a stream community. I found no significant difference in the breakdown rates of leaf litter (*Acer rubrum*) ($P = 0.42$) and mean functional feeding group composition ($P = 0.587$) between treatments. However, total number of shredders were most abundant in crayfish only treatments and were the least abundant when crayfish and gobies were together. This indicates that the presence of round gobies directly affected the number of shredders but not enough to indirectly affect the next trophic level. *Keywords: Round goby, Crayfish, Macroinvertebrates, Trophic level.*

TEPAS, K.M.[1] and HINCHEY, E.K.[2], [1]Illinois-Indiana Sea Grant, USEPA GLNPO, 77 W. Jackson Blvd., G-17J, Chicago, IL, 60604, USA; [2]USEPA Great Lakes National Program Office, 77 W. Jackson Blvd., G-17J, Chicago, IL, 60604, USA. **Live, From The Field, It's Great Lakes Science!.**

"I used to think science sucks but now I know it doesn't," commented a high school student after participating in a videocall with IL-IN Sea Grant and USEPA Great Lakes National Program Office. Thanks to easy WiFi access and programs such as Google Hangout or Skype, connecting virtually with others is easier than ever. Why not use this technology to share your research and ignite interest in science and the Great Lakes in young minds! These virtual experiences can be done from the field, in your lab or even from your office. For a small investment of your time, the benefits are ten-fold. Students see firsthand the application of science: "It was a cool way to see how someone is using the science that we are learning right now." Students become more aware of careers: "I am curious about how I can get a job doing this." Science is made more accessible: "We got to talk to real life scientists, we actually interacted with them." And you may inspire others and build goodwill within a community: "Everyone has been talking about what a wonderful and valuable experience that you provided our community. Your passion and ability to communicate your knowledge to students and teachers is inspiring." In our presentation we'll share best management practices for setting up and conducting engaging videocalls with K-12 classrooms. *Keywords: Education, Environmental education, Outreach.*

TESFAYE, T.E., Eastern Nile Technical Regional Office (ENTRO), Addis Ababa, St, 1000, 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, issues of 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 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. Examples The study ends with a set of recommendations that can be used by information professionals and other stakeholders in Nile Basin countries to organize the way forward for the application, growth and development of digital libraries as a means of cooperation for the efficient utilization of the common Nile. *Keywords: Water distribution, Data storage and retrieval, Africa.*

TESSIER, L.R., WHITE, C., and WILKIE, M.P., Wilfrid Laurier University, 75 University Ave W, Waterloo, ON, N2L 3C5, CANADA. **Effects of Body Size & Life Stage on TFM Uptake, Excretion & Metabolism in Sea Lamprey (*P. marinus*).**

Invasive sea lampreys are a jawless fish that feed on the blood and bodily fluids of large sport fish in the Great Lakes. Sea lamprey populations are primarily controlled using TFM; It is applied to streams where larvae are present in high densities. Sea lamprey that survive treatments and undergo metamorphosis are termed residual lamprey, but some factors accounting for their survival are unresolved. The current study tested the hypothesis that differences in body sizes and life stage, leading to differences in TFM uptake and excretion rates, could be a potential source of residual sea lamprey. The largest larval sea lampreys were found to have the lowest TFM uptake rates (3.4+/-0.5 nmol/g/h), which correlated to their low metabolic rates (1.5+/-0.2 umol O2/L/h). No life-stage specifics for either metabolic rates or TFM uptake rates were detected. Surprisingly, body size did not influence TFM excretion rates, but the larvae and post-metamorphic sea lamprey excreted most of the TFM taken up (92-96%) after 24 hours following the administration of 14C-TFM by interperitoneal injection. However, larger larval sea lampreys also survived longer during 24hr toxicity tests compared to smaller sea lamprey (P=0.4). Therefore, body size and life stage may influence the effectiveness of a TFM treatment and probability of residual lamprey. *Keywords: Toxic substances, Invasive species, Fisheries.*

THOMA, S.M. and MCNAUGHT, A.S., Central Michigan University, 217 Brooks Hall, Mount Pleasant, MI, 48859, USA. **The Role of *Hemimysis anomala* in the Nearshore Food Webs of Lakes Michigan and Huron.**

The invasive crustacean *Hemimysis anomala*, exhibits behavioral and life history traits that may enable it to substantially alter the near shore food web of the Great Lakes. *Hemimysis* is known to feed voraciously on lower food web organisms; however, it may also serve as a new resource for fish, thereby creating a link between littoral and pelagic food webs. We used stable isotope analysis to assess trophic interactions at 7 near shore sites in Lakes Michigan and Huron that span a range of *Hemimysis* densities. Mysid density was measured monthly June-Aug. 2013 at night via vertical net haul. Fish species (round goby, rock bass, and smallmouth bass) and invertebrates representing common fish prey were collected at each site Sept.-Oct. 2013 and analyzed for carbon and nitrogen isotopes (13C and 15N). A Bayesian mixing model showed that *Hemimysis* contributed 31-57% of round goby and 23-70% of rock bass diets, but never more than 38% of smallmouth bass diets. The proportional contribution of *Hemimysis* to fish diets increased with *Hemimysis* density for round goby and rock bass but not for smallmouth bass. Our results suggest that *Hemimysis* may be able to lengthen food webs, with its role becoming more pronounced for certain fish species in systems where mysid densities are high. *Keywords: Invasive species, Stable isotopes, Food chains.*

THOMAS, K.E.[1], CHAMBERS, P.A.[2], CULP, J.M.[2], and YATES, A.G.[1], [1]Western University, 1151 Richmond St, London, ON, N6A 3K7, CANADA; [2]Environment and Climate Change Canada, 867 Lakeshore Road, Burlington, ON, L7S1A1, CANADA. **Development of nutrient criteria for tributaries of Lake Erie: a field and mesocosm approach.**

Excessive phosphorus, largely from tributary inputs, is causing harmful algal blooms and other deleterious changes in ecosystem condition of Lake Erie. The goal of this study was to develop nutrient criteria for tributaries of Lake Erie in order to provide management guidelines for taking action on nutrient sources and tracking ecological recovery. Chemical and biological samples were collected, April through November 2012, from 29 streams in Lakes Erie and Huron watersheds. Preliminary analyses of this field data, combined with historical monitoring data, identified TP concentrations of 25 - 30 μg/L as protective of stream ecological condition. To validate these criteria, P-dosing experiments were conducted in the Western University Thames River Experimental Stream Systems (TRESS) Centre in which 6 artificial streams were dosed with a specific concentration of P (+0, +10, +25, +50, +100, +150 μg/L above background concentrations - 0.0014 μg/L). Over the 4 week experiment, ecological structure (e.g., algal taxonomy, pigment composition) and function

(e.g., metabolism, decomposition) were measured. Preliminary results of benthic chlorophyll-*a* and dissolved oxygen concentration from the artificial stream experiments indicated a change in the biological community between 10 - 50 µg/L. *Keywords: Nutrients, Mesocosm, Water quality, Experiments, Watersheds.*

THOMPSON, B. and LEMBCKE, D., Lake Simcoe Region Conservation Authority, 120 Bayview Parkway, Newmarket, ON, L3Y 3W3, CANADA. **Developing a Multi-Sectoral Approach to Reduce Chloride Loading in the Lake Simcoe Watershed.**

Chloride, associated with the use of salt to manage ice and snow on roads and parking lots, is rapidly emerging as a leading concern for the ecological health of many of Ontario's lakes and rivers. In Lake Simcoe, a steadily increasing trend in chloride concentrations has been documented since the 1970s (Winter et. al 2011). Within the lake's tributaries, it is not uncommon to see chloride concentrations exceed the acute toxicity guideline of 640 mg/l numerous times during winter months. While the highest chloride concentrations coincide with winter application, concentrations that exceed the chronic guideline of 120mg/l persist in many urban rivers year round. Since 2013, the Lake Simcoe Region Conservation Authority and its partners have been conducting research and monitoring to further understand the sources of chloride within our watershed. This information has allowed us to develop a multi-sectoral strategy for chloride reduction that addresses risks associated with both existing and future land uses. The strategy includes direction on both structural (i.e. land development) and operational (municipal and private sector) aspects of snow and ice management. *Keywords: Ecosystem health, Chloride, Management, Urban watersheds.*

THOMPSON, M.A., WINTER, C.L., ARMSTRONG, M.R., and LABUHN, S.L., University of Wisconsin Milwaukee, 600 E. Greenfield, Milwaukee, WI, 53204, USA. **Carbon budget of Mangroves in Freshwater and Brackish Systems of the Yucatan Peninsula.**

Mangroves are a very important carbon sink because they have a remarkably great ability to filter and sequester carbon. However, due to human industry, development, tourism, climate change, etc., mangrove forests are starting to disappear. Proper protection could be a significant factor in reducing the effects of greenhouse gases on climate change. The eastern Yucatan Peninsula has complex system of estuarine-coastal lagoons, brackish lagoons, and freshwater karstic lagoons that contain mangroves. A preliminary effort has begun to quantify and further understand the carbon budget of the mangroves in the Yucatan Peninsula area of Mexico. Included is Mexico's second largest freshwater lake, Laguna Bacalar, and the largest estuarine-coastal lagoon, Chetumal Bay. Above ground biomass, below ground biomass, downed woody debris, seedling/sapling, and soil carbon data were collected from seven different sites in Laguna Bacalar and Chetumal Bay. These sites varied in location, hydrology, mangrove species, and forest type. In the freshwater area of Laguna Bacalar, it was found that dwarf mangroves dominated the forest sample sites. In Chetumal Bay, a brackish environment, medium to tall mangroves were most prevalent. *Keywords: Carbon, Wetlands.*

THORN, C.E. and MCLEOD, T.K., Bruce Peninsula Biosphere Association, 16 Brock Street PO Box 3, Tobermory, ON, N0H 2R0, CANADA. **Six Streams Initiative: A Community Driven Water Quality Outreach Program.**

The Bruce Peninsula is the second highest priority for Great Lakes conservation on both sides of the border (NCC, MNR's Great Lakes Conservation document and the International Biodiversity Conservation Strategy for Lake Huron) but has no Conservation Authority to lead stewardship efforts. An NGO, the Bruce Peninsula Biosphere Association mobilized local farmers, cottagers, students, government and academic partners in an interdisciplinary effort to improve water quality. Over 3 years the multi-pronged Six Streams Initiative has featured stream nutrient, particulate and benthic sample collection by "citizen scientist" volunteers certified as water quality collection technicians, established 47 solar powered nutrient-loading prevention systems and landowner demonstration-based workshops. By equipping and motivating community stakeholders to address water quality issues, the Initiative has shaped practices that directly improved water quality. Phosphorus loading has been reduced by ~730 kg by fencing over 3300 cattle out of four watercourses. Septic systems along watercourses are better managed and underperforming systems are being repaired. Vegetative buffers, innovative water level drain control structures and BMP agricultural systems are reducing soil erosion. This presentation will share our stakeholder engagement strategy. *Keywords: Conservation, Ecosystem health, Organizations.*

TODD, K., DAMAIA, S., GAIOT, J., and KELLEHER, S., Ontario Ministry of Natural Resources and Forestry, 300 Water St, 2 North, Peterborough, ON, K9J 8M5, CANADA. **Ontario's Water Resource Information: An Update on Spatial Data, Tools and Applications.**

Ontario's Spatial Data Infrastructure (SDI) section of the Ontario Ministry of Natural Resources and Forestry is responsible for capturing, creating and maintaining Ontario's fundamental mapping data. This presentation will overview several projects that have been prioritized within SDI to support science, policy and planning priorities within the

Great Lakes basin. A number of technological advances will also be highlighted that have allowed for significant improvements in imagery and elevation data acquisitions, which allow for a range of geospatial products, such as hydrography, elevation, wetland, and watershed data, to be updated. The structure and maintenance models tied to the Ontario Hydro Network (OHN) and Ontario Integrated Hydrology (OIH) data products will be discussed, which serve as authoritative data sources for mapping and analysis of Ontario's water resources. Examples will also be highlighted where SDI's data products have been used for assessing water quality and water quantity and developing decision-support systems within the Great Lakes basin. *Keywords: GIS, Hydrologic cycle, Watersheds.*

TORBICK, N.T., CORBIERE, M.M., and ZINITI, B.L., Applied Geosolutions, Newmarket, Ne, 03857, USA. **Mapping spatiotemporal changes in lake temperature in the northeast USA.**

We used Landsat 'BigData' to map lake skin temperature trends across the entire northeast USA. A suite of spatial regression models and geostatistical techniques were employed to understand spatial and temporal patterns. The second objective was to test weather and geographic factors as influential drivers of lake skin temperature patterns using hierarchical spatiotemporal modeling. This effort provides the first regionally focused and comprehensive spatiotemporal assessment of thousands of lakes concentrated in one region. We relied on the MODerate resolution atmospheric TRANsmission (MODTRAN) radiative transfer model (v5.3) parameterized with custom atmospheric profiles (vertical profile) retrieved from the Modern Era Retrospective-Analysis for Research and Applications (MERRA) data. The atmospheric profiles included absorbing gas, H2O, and Ozone mixing ratios for approximately 60 pressure layers. Spatial regression and Bayesian Hierarchical Modeling was applied in a complementing approach. Lakes in northern New England show warming during summer months on the order of 1 degree C / decade. This effort provides the first regionally focused and comprehensive spatiotemporal assessment of thousands of lakes concentrated in one region. The approach is scalable and potentially adaptable to any region for assessing lake temperature. *Keywords: Remote sensing, Temperature, Ecosystem modeling.*

TRAN, K. and ACKERMAN, J.D., University of Guelph, 50 Stone Road, Guelph, ON, N1G2W1, CANADA. **Selective Feeding of Freshwater Mussels: Implications for Resource Partitioning.**

The clearance rate *(CR)* of the freshwater mussels *Ptychobranchus fasciolaris* (a species at risk, conservation concern) and *Lasmigona costata* (a commonly occurring species) were examined under static conditions (no flux) and high flux conditions in a flow chamber using water from the Sydenham River, ON. *CR* was assessed from the decline in chlorophyll *a* concentration at the beginning vs. the end of an experiment using a calibrated fluorometer and the abundance of algal taxa was also identified using an imaging flow cytometer (FlowCam). Of the 17 algal taxa identified, 5 were in relatively high abundance at the beginning of experiments consistently, to facilitate the determination of *CR*. The *CR* based on the chlorophyll *a* was generally higher (1) under high flux vs. no flux and (2) for *P. fasciolaris* vs. *L. costata*. The particle selection based on the change in algae abundance shows that under high algal flux conditions *P. fasciolaris* has a higher *CR* for *Nitzchia* and an unidentified *Epiphytic diatom* than *L.Costata*. The difference in feeding ability between two species indicate possible resource partitioning and further understanding of their feeding requirements may provide us with better conservation methods. *Keywords: Algae, Mussels, Species diversity.*

TREBITZ, A.[1], HOFFMAN, J.[1], PETERSON, G.[1], PILGRIM, E.[2], MARTINSON, J.[2], LIETZ, J.[3], HATZENBUHLER, C.[3], OKUM, S.[3], ZHANG, S.[3], and MEREDITH, C.[4], [1]U.S. EPA Mid-Continent Ecology Division, Duluth, MN, USA; [2]U.S. EPA National Exposure Research Laboratory, Cincinnati, OH, USA; [3]ORISE fellows at U.S. EPA, Duluth, MN, USA; [4]NRC fellow at U.S. EPA, Duluth, MN, USA. **Challenges and Progress in Making DNA-based Monitoring Operational - AIS Early Detection as Testbed.**

The ability of DNA barcoding to find additional species in hard-to-sample locations or hard-to-identify samples is well established. Nevertheless, adoption of DNA barcoding into regular monitoring programs has been slow, in part due to issues of standardization and interpretation that need resolving. In this presentation, we describe our progress towards incorporating DNA-based identification into broad-spectrum aquatic invasive species early-detection monitoring in the Laurentian Great Lakes. Our work uses community biodiversity information as the basis for evaluating survey performance for various taxonomic groups. Issues we are tackling in bringing DNA-based data to bear on AIS monitoring design include: 1) Standardizing methodology and work flow from field collection and sample handling through bioinformatics post-processing; 2) Determining detection sensitivity and accounting for inter-species differences in DNA amplification and primer affinity; 3) Differentiating sequencing and barcoding errors from legitimate new finds when range and natural history information is limited; and 4) Accounting for the different nature of morphology- vs. DNA-based biodiversity information in subsequent analysis (e.g., via species accumulation curves, multi-metric indices). *Keywords: Species composition, Invasive species, Biomonitoring.*

TRUONG, J.W.[1], DIAMOND, M.L.[2], JANTUNEN, L.M.[3], and HELM, P.[4], [1]Department of Chemical Engineering, University of Toronto, 200 College St, Toronto, On, M5S 3E5, CANADA; [2]Department of Earth Sciences, University of Toronto, 22 Russell Street, Toronto, On, M5S 3B1, CANADA; [3]Air Quality Processes Research Section, Environment Canada, 8th line, Egbert, On, L0L 1N0, CANADA; [4]MOECC, 125 Resources Rd, Toronto, On, M9P 3V6, CANADA. **Tris(chloropropyl) Phosphate (TCPP) in Toronto Tributaries, Rain and Waste Water Effluent.**

Organophosphate esters (OPEs) are chemical additives that can be released from products into the environment via volatilization, dissolution and abrasion. OPEs are a concern because of recent reports of high concentrations indoors, in surface waters, and their potential toxicity to aquatic biota and humans. We documented concentrations of TCPP, the highest OPE measured in the environment in three Toronto tributaries during high and low flow periods, and in final effluent from three waste water treatment plants (WWTP). TCPP in WWTPs had the highest average concentrations (6.6 ± 11 μg/L, 0.054 - 18 μg/L), followed by tributaries during high flow periods (4.2 ± 3.9 μg/L, 0.22-11 μg/L), then tributaries during low flow periods (0.86 ± 0.95 μg/L, 0.11-6.8 μg/L), and then rain (0.60 ± 0.98 ug/L, 0.005 - 2.3 ug/L) (ANOVA, $p<0.05$). Mean TCPP concentrations in tributaries differed from each other only during high versus low flow periods (ANOVA, $p<0.05$). TCPP concentrations in tributaries correlated with water discharge rate (m3/s) (Pearson $r = 0.65$). Unlike PBDEs, TCPP concentrations were not correlated with turbidity in Toronto tributary water ($r = 0.2$) and a negative correlation was observed with suspended solids ($r = -0.6$). *Keywords: Environmental contaminants, Lake Ontario.*

TURGEON, K.[1], REID, K.B.[2], NUDDS, T.D.[1], and FRYXELL, J.M.[1], [1]University of Guelph, 50 Stone Road E, Guelph, ON, N1G 2W1, CANADA; [2]Ontario Commercial Fisheries' Association, 45 James St, Blenheim, ON, N0P 1A0, CANADA. **Compensatory responses of managers and harvesters to changes in Lake Erie walleye abundance.**

Relative to other sources of uncertainty about variation in stock size, that related to responses by managers and harvesters) is rarely considered. Theory predicts, however, that weak or delayed compensatory responses in quota adjustments, or to effort and harvest, to changes in stock abundance may induce unstable population dynamics, increasing the risk of fishery decline. We examined the magnitude and direction of annual rate of change in quota (manager response) and effort and harvest (recreational and commercial harvesters' responses) to change in stock size of Lake Erie walleye over 39 years. With some exceptions, annual rates of change in quota tracked those of walleye stock size. Nevertheless, commercial harvest was strongly entrained by quotas, such that a small number of consecutive quota adjustments not scaled in magnitude and direction to changes in walleye

abundance resulted in a mismatch between stock size and commercial effort and harvest for roughly 10 years. In contrast, recreational effort and harvest were not entrained by quota and more closely tracked stock size, perhaps as a result of rapid information sharing about fishery status and angling quality among a large pool of harvesters. *Keywords: Walleye, Lake Erie, Fish management.*

TUTTLE, T.[1], DAVIS, T.W.[2], MCKAY, R.M.[1], and BULLERJAHN, G.S.[1], [1]Bowling Green State University, Biological Sciences, Bowling Green, OH, USA; [2]NOAA GLERL, Ann Arbor, MI, USA. **Seasonal investigation of the Planktothrix cyanobacterial bloom community in Sandusky Bay.**

Sandusky Bay is subject to blooms of Planktothrix that are of longer duration than the annual Lake Erie Microcystis blooms. Being a less studied potential toxin producer, it is not yet known how and why Planktothrix is successful in the nitrogen-limited environment of Sandusky Bay. To investigate, 6 sites ranging from the far inner bay to the outer bay were sampled weekly from June through October 2015 for nutrients, chl a, microcystins, and DNA. Toxin analyses indicated no correlation between chlorophyll a and microcystin concentration. The trend in nitrate concentration was a transition from a peak in June to a decrease to below detection by October. The June nitrate maximum coincided with heavy rain events, and the decline was linked to active denitrification in bay sediments. qPCR assays showed no trend between microcystin concentration and the percent of toxin-producing Planktothrix. 16S iTag data obtained throughout the year show microbial community composition for the bay over time, providing insights into bacterial/cyanobacterial interactions over the bloom season. Further studies are aimed at elucidating triggers for toxin production and monitoring succession of Planktothrix genotypes through the year. This may allow better predictability of the presence of toxins in order to alert water treatment facilities. *Keywords: Cyanophyta, Planktothrix, Nutrients, Lake Erie.*

TUTTLE-RAYCRAFT, S. and ACKERMAN, J.D., University of Guelph, 50 Stone Road E, Guelph, ON, N1G 2W1, CANADA. **The Effect of Suspended Sediment Flux on the Suspension Feeding of a Freshwater Mussel.**

The effect of suspended sediment (SS) flux on suspension feeding of the freshwater mussel *Lampsilis siliquoidea* was examined in a laboratory flow chamber using different combinations of sediment concentration (C) and velocity (U). The response of clearance rate (CR) to SS flux was nonlinear and varied on the response surface defined by velocity and concentration. CR generally increased with velocity whereas they declined with increased SS concentration. However, the response was not uniform; concentration had a greater influence on CR at low velocity, as did velocity when concentrations were low. One example of this relationship is that the CR was 67% lower than the no-flux control at 5000 mg m^{-2} s^{-1} (high C x low U). The CR was only 31% lower than the control when the flux was increased to 25 000 mg m^{-2} s^{-1} (high C x high U). This demonstrates that that the relationship between SS and suspension feeding is likely more complicated than previously demonstrated in studies that focus on concentration alone. The interaction of C and U provides an example of how multiple stressors affect organisms in nature. *Keywords: Unionids, Sediment load, Hydrodynamics.*

TWISS, M.R. and STRYSZOWSKA, K.M., Clarkson University, Potsdam, NY, 13699, USA. **Current status of Emerging Technologies in the LGL-SLR: Results of a basin-wide survey in 2015.**

A survey of operators of emerging technologies used to monitor water quality and environmental conditions in the Great Lakes was conducted over a three week period in 2015. Data were summarized with the aim to provide insight into the approximate timelines and the level of investment needed by the governments in order to sustainably operationalize configurations of these emerging technologies. *Keywords: Monitoring, Emerging technology, Great Lakes basin, Data acquisition.*

TYLER, A.C.[1], CADY, B.[3], CADY, M.A.[3], CELESTE, J.[4], FORNOF, N.[2], WAUD, J.M.[1], ZAYATZ, R.[2], LODGE, K.A.[1], and WILLIAMS, T.E.[1], [1]Rochester Institute of Technol, 85 Lomb Memorial Drive, Rochester, NY, 14618, USA; [2]Waste Management of New York, LLC, 425 Perinton Parkway, Fairport, NY, 14450, USA; [3]High Acres Nature Area, 425 Perinton Parkway, Fairport, NY, 14450, USA; [4]Earth Dimensions, Inc, 1091 Jamison Rd, Elma, NY, 14059, USA. **Partnerships for Wetland Restoration to Achieve Regulatory, Conservation and Educational Goals.**

The High Acres Nature Area (HANA) is a 400 acre wetland-upland complex in Perinton, NY owned and managed by Waste Management of New York, LLC (WM). The site is open for public use and stewardship is aided by an active group of volunteers. In 2009 and 2012, wetlands were created to mitigate nearby landfill expansion. In 2011, faculty and students at the Rochester Institute of Technology (RIT) partnered with HANA to further conservation, research and education. Students conduct hands-on restoration activities and restoration ecology research. Development of a Weed Management Plan and Conservation Action Plan has been incorporated into coursework. Students gain experience with restoration, communication among stakeholders, conservation planning, and research. Funding from WM has been matched by grants from the EPA's Five Star program, Keep America Beautiful, and the National Center for Science and Civic Engagement's Great Lakes

Innovative Stewardship Through Education Network (GLISTEN) project, with funds from the Corporation for National and Community Service. The site won the Corporate Lands for Learning award from the Wildlife Habitat Council in 2012 and 2015. This corporate-volunteer- higher education partnership is a successful model to achieve regulatory performance criteria, conservation goals, and educational outcomes. *Keywords: Wetlands, Restoration, Education.*

U

UDUMA, U.A., MCBEAN, E.A., and GHARABAGHI, B., University of Guelph, 50 Stone Road East, Guelph, ON, N1G 2W1, CANADA. **Risk assessment of Cyano-toxins for small drinking water treatment plants in Québec and Alberta.**

A hazard index approach to risk characterization is employed to analyze the effectiveness of three conventional treatment methods, in relation to the removal of cyanotoxins for small drinking water treatment plants in Québec and Alberta. Hazard risk indices greater than unity, indicating a concern, are indicated as having been estimated for both an adult (70kg body weight) and a baby (10kg body weight) for the scenario involving consumption of raw water, shellfish and dairy supplies from all the test cases considered. However, adjustments in consumption involving treated drinking water and dairy resulted in hazard indices less than unity for communities in Alberta. The adoption of a holistic management approach that integrates cyanobacterial bloom management, membrane filtration and ozonation is the recommended effective treatment method for small drinking water treatment plants for these study regions. *Keywords: Hazard Index, Removal Technologies, Human health, Risk assessment.*

UZARSKI, D.G., SCHOCK, N., GEHRING, T.M., and WHEELOCK, B.A., Central Michigan University Institute for Great Lakes Research, Brooks 127, Mount Pleasant, MI, 49340, USA. **Faucet snail (*Bithynia tentaculata*) occurrence across the Great Lakes basin in coastal wetlands.**

The faucet snail (Bithynia tentaculata) was introduced into the Great Lakes in the late 1800's, likely via hard ballast used by the shipping industry. In addition to altering native invertebrate communities, the faucet snail acts as the intermediate host for three intestinal flukes that cause mortality when ingested by waterfowl. Although faucet snails had been established in the Great Lakes for over 100 years, populations remained relatively low. Recent monitoring efforts have shown that they are much more widespread than previously documented. Few individuals were collected from Saginaw Bay in the 1980's and 1990's. We

have surveyed coastal wetlands of Saginaw Bay since 1999 and did not collect any faucet snails until 2010. Since that time, the collection of B. tentaculata has been commonplace. During the same time-period, wet meadow habitat was invaded by Phragmites australis. Preliminary data suggests that densities of B. tentaculata are greatest in P. australis. We hypothesize that the expansion of P. australis, along with other changes in environmental conditions, has contributed to the proliferation of this invasive species, altered invertebrate communities across the basin, and has exacerbated the threat of waterfowl mortality.
Keywords: Invasive species, Coastal wetlands, Monitoring.

V

VALIPOUR, R., LEON, L., DEPEW, D., YERUBANDI, R., DOVE, A., and MCCRIMMON, C., Environment Canada, 867 Lakeshore Rd., Burlington, On, N2L3G2, CANADA. **High-Resolution Modeling for Developing Nearshore Ecosystem Objectives in Lake Erie: Hydr&WatQuality.**

Extensive nearshore field measurements were carried out in the vicinity of the Grand River (eastern Lake Erie) during 2012 and 2013. We applied a high resolution (600 m grid) 3D water quality model for Lake Erie capable of resolving main physical processes to study nutrients dynamics, with a particular emphasis on coastal waters. The model was used to develop response curves for nuisance algae biomass (Cladophora) in the vicinity of the Grand River. Results revealed that P concentrations in nearshore regions are governed by a combination of external runoff loads and nutrient exchange with the offshore. The model resolved the predominant physical processes that occur within the Cladophora habitat zone (0-8m depth) and, with near shore hydrodynamic processes at a high resolution, we showed that Cladophora blooms is sustained by phosphorus originating from local sources (i.e. tributary inputs) but also from offshore waters, which reflects whole-lake loading. Furthermore, the relative influence of these sources is not constant and likely changes on a year to year basis. The high resolution modeling approach used here offers a practical means to assimilate the complex and spatially variable ecosystem information and examine the effects of alternative management strategies to provide credible P loads to achieve ecosystems objectives *Keywords: Lake Erie, Water quality, Model studies.*

VAN METER, K.J.[1] and BASU, N.B.[2], [1]Department of Earth and Environmental Sciences, 200 University Ave. W., Waterloo, ON, N2L 3G1, CANADA; [2]Department of Civil and Environmental Engineering, 200 University Ave. W., Waterloo, ON, N2L 3G1, CANADA. **Confounding Complexity or Emerging Simplicity: Biogeochemical Regimes in Anthopogenic Watersheds.**

Watersheds demonstrate a range of both chemostatic and chemodynamic responses to changes in discharge based on land use, solute species, and hydrologic regime. The dynamics of solute export, as captured by concentration-discharge patterns, can be described mathematically based on a power-law concentration-discharge relationship of the form $C=AQ^b$. We hypothesize that different solute export regimes are created primarily as a function of solute mass stores in different compartments of the landscape, e.g. the vadose zone or groundwater, and that these regimes may vary temporally based on triggering of these compartments as a function of stochastic forcing within and between years. In the present work, we synthesize both high and low temporal resolution concentration data to better our understanding of the variations in concentration-discharge relationships as a function of land use, climate and solute type. We then develop a modeling framework allowing us to address the following questions: (1) How do C-Q relationships vary across climate and land-use gradients? (2) Is there any seasonality to C-Q patterns? (3) How do these interactions lead to the development of hot spots and hot moments in catchment biogeochemical processing? *Keywords: Nutrients, Biogeochemistry, Watersheds.*

VAN PATTER, J. and COCKBURN, J.M.H., Department of Geography, University of Guelph, Guelph, ON, CANADA. **Evaluating suspended load flux after a 500-year runoff event.**

Climate variability in the Great Lakes region is generating more frequent intense rainfall events. Extreme rainfall can have lasting impacts on rivers and lakes by introducing more sediment to these systems. Suspended sediment transfers may be greater following extreme rainfall events and consequently damage benthic habitat and degrade water quality. In this study we use discharge and suspended sediment yield from the Schoharie Creek (~2300 km^2), north slope of the Catskill Mountains, New York State, following the 2011 Tropical Storms Irene and Lee as an analogue to similar watersheds throughout the Great Lakes Basin to investigate longer-term impacts of extreme rainfall on suspended load flux. The 2011 storms generated extreme rainfall in the watershed (over 450 mm in 24 hours), which lead to runoff on August 29 that exceeded the 500-year recurrence interval. Discharge and suspended load data were evaluated through the 2013-15 water years. Preliminary results suggest the suspended load response to discharge was relatively unchanged through the study period, regardless of runoff magnitude or seasonality, indicating no sediment exhaustion even years after extreme rainfall. However, the expected increase in the frequency of these events will contribute to overall deposition in downstream basins. *Keywords: Watersheds, Extreme runoff, Sediment transport, Climate change.*

VANDEN BYLLAARDT, J.[1], ADAMS, J.[2], CASAS-MONROY, O.[1], and BAILEY, S.A.[1], [1]Fisheries and Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7S 1A1, CANADA; [2]University College London, Gower Street, London, WC1E 6BT, ENGLAND. **Dead or alive? Developments in the detection of aquatic invasive species in ballast water.**

Regulatory discharge standards stipulating a maximum allowable number of viable (live) organisms in ballast water have led to a need for rapid compliance assessment protocols that enumerate potentially invading organisms in any sample of water. Traditional methods of preserving and enumerating the total number of organisms assume that all intact organisms were alive at time of collection. This assumption may not prove true, particularly in ships' ballast tanks where environments may be harsh and transit times may be too long for many organisms to survive, leading to overestimates of live plankton abundance. Here, we compare the detection abilities of emerging technology in ballast water monitoring, including vital staining (fluorescein diacetate) and pulse amplitude modulated (PAM) fluorometry. To make this comparison, we collected ballast water samples from 15 commercial ships sourced from a variety of marine and fresh water ports, and analyzed in situ phytoplankton densities (of those ≥10 and < 50 μm in minimum dimension) using the described methods. Discussion will include a comparison of the measurement error and utility of each technique to detect viable organisms. *Keywords: Phytoplankton, Ballast, Invasive species.*

VANDER WOUDE, A.J.[1], STUART, D.G.[2], RUBERG, S.A.[1], JOHENGEN, T.H.[1], MCCARTY, B.[3], CHURNSIDE, J.H.[3], PALLADINO, D.[1], and BURTNER, A.[1], [1]Cooperative Institute for Limnology and Ecosystem Research, University of Michigan, Ann Arbor, MI, USA; [2]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, USA; [3]NOAA ESRL Chemical Sciences Division, Boulder, CO, USA. **Chlorophyll a and Phycocyanin from Hyperspectral Airborne and Hand-held Sensors on Lake Erie.**

The optical complexity of Lake Erie is influenced by seasonal variations in colored dissolved organic material, dissolved organic matter, suspended sediment, detritus and phytoplankton. During the late summer to fall months, a characteristic cyanobacteria bloom develops in the Western basin of Lake Erie. This bloom has negatively influenced water intake facilities located in the basin. To alert facility managers of blooms located near water intake locations, a sophisticated hyperspectral detection system was developed. The hyperspectral detection of cyanobacteria blooms at weekly time scales can be achieved by estimating the biomass (chlorophyll a) and by also determining the portion of the bloom that was cyanobacteria with an estimation of phycocyanin. Two hyperspectral imagers, Resonon's airborne hyperspectral imaging system (HSI) with the Pika II imaging camera and the Satlantic hand-held Hypergun, were deployed during the summer of 2015. Algorithms for chlorophyll a and phycocyanin were compared with the laboratory analyzed values and the hyperspectral sensors to determine which one behaved the best for these complex waters. The 2015 coincident NASA airborne HSI overflights were also compared with the Resonon airborne sensor to define the efficacy of both sensors to detect cyanobacteria blooms. *Keywords: Lake Erie, Microcystis, Remote sensing.*

VANDERPLOEG, H.A.[1], CAVALETTO, J.F.[1], BALDRIDGE, A.K.[1], BURLAKOVA, L.E.[2], CARRICK, H.J.[3], KARATAYEV, A.Y.[2], LANG, G.A.[1], LIEBIG, J.R.[1], MASON, D.M.[1], NALEPA, T.F.[4], POTHOVEN, S.A.[1], ROWE, M.D.[5], RUTHERFORD, E.S.[1], and WELLS, D.J.[5], [1]NOAA Great Lakes Evironmental Research Laboratory, 4840 S. State Road, Ann Arbor, MI, 48108, USA; [2]Great Lakes Center, Buffalo State College, Buffalo, NY, 14222, USA; [3]Central Michigan University, Mount Pleasant, MI, 48859, USA; [4]Water Center, University of Michigan, Ann Arbor, MI, 48104, USA; [5]Cooperative Institute for Limnology and Ecosystems Research, Ann Arbor, MI, 48108, USA. **Spatial Organization of Pelagic and Benthic Food Webs in Southern Lake Michigan in 2015.**

We examined spatial coupling of nutrients and the entire pelagic food web--microbes to fishes--day and night at monthly intervals April through October along a 30-km inshore to offshore transect near Muskegon, MI, using a variety of advanced tools including plankton survey system (PSS) and fishery acoustics. In addition we determined spatial distribution and biomass of benthos throughout Lake Michigan. The PSS mapped out fine-scale diel vertical distribution of temperature, chlorophyll, light, turbidity, and zooplankton biomass along the transect. Stratification was slow to set up in 2015, and in late spring the plankton was concentrated nearshore and in the epilimnion. Later, chlorophyll and plankton maxima were associated with the metalimnion, and larger zooplankton were found offshore. Daphnia exhibited extreme diel vertical migration in late summer. Preliminary results suggest that larval fish distribution matched that of their zooplankton prey. We will report biomass of dreissenids in the southern basin and compare it with the spatial distribution of nutrients, chlorophyll, and lower trophic level biomass from earlier years. *Keywords: Lake Michigan, Monitoring, Food chains.*

VANNIJNATTEN, D.L., Wilfrid Laurier University, 75 University Ave. W, Waterloo, ON, N2L 3C5, CANADA. **Fashioning Indicators for the Basin Context: Outcome, Output and Governance Indicators.**

The revised Great Lakes Water Quality Agreement places increased focus on collaboration, engagement (both across levels of government and tribes/native bands, and with nongovernmental stakeholders), coordination and reporting. These are governance functions which are horizontal, cutting across the specific environmental quality concerns that are considered especially in the various Annexes to the Agreement. It is important to assess these governance functions, since they are critical to achieving success across environmental issues, across the Basin. As Kaufmann & Kraay (2008) note: "The gravity of the issues dealt with in definitions of governance suggests that measurement is important." This paper will discuss, first, how indicators for "governance" differ from "outcome" (e.g. ecosystem and human health) indicators or "output" (program response) indicators; governance indicators provide a means of connecting the EI, HHI and PEI with social and human behavioural change. Second, the paper will discuss how they can help us measure the degree to which, or how well, the governance arrangements in place support the Agreement's General and Specific Objectives but also the Annex mandates in terms of current implementation, and the prospects for the future. *Keywords: Indicators, Governance, Policy making.*

VARGA, S.[1] and KISSEL, A.[2], [1]Ontario Ministry of Natural Resources & Forestry, Aurora District, 50 Bloomington Road, Aurora, ON, L4G 0L8, CANADA; [2]Ontario Streams, 50 Bloomington Road, Aurora, ON, L4G 0L8, CANADA. **Critical Baseline Data on Wetlands in the Lake Simcoe Watershed.**

Wetlands in the entire Lake Simcoe watershed were mapped and their vegetation characterized by means of air-photo interpretation using multiple years of spring ortho-rectified imagery at 20 cm pixel resolution, summer infrared imagery and DEM derived contours supplemented by roadside checks. The mapping resulted in finding an additional 5,561 hectares of wetlands bringing the total to 52,416 ha, or 16% of the watershed around the lake. Wetlands play a critical role in reducing nutrient impacts to Lake Simcoe and in benefiting both aquatic and upland ecosystems. Approximately 56% of the wetlands have been evaluated using the Ontario Wetland Evaluation System methodology with the focus on evaluating wetlands in areas being proposed for development. Aerial imagery is now being used to systematically determine wetland losses and gains and their causes over the past 15 years across the watershed. Losses have occurred due to agricultural drainage, peat extraction, fill and development, while there have been some gains from agricultural abandonment. *Keywords: Lake Simcoe, Wetlands.*

VASQUEZ, A.A.[1], HUDSON, P.L.[2], FUJIMOTO, M.[1], KEELER, K.[2], ARMENIO, P.M.[2], and RAM, J.L.[1], [1]Wayne State University School of Medicine Department of Physiology 5374 Scott Hall, 540 E. Canfield Street, Detroit, MI, 48201, USA; [2]Great Lakes Science Center, U. S. Geological Survey, 1451 Green Road, Ann Arbor, MI, 48105, USA. **Biogeography of *Eurytemora carolleeae* in the Great Lakes revealed by phylogeny and morphology.**

In the Laurentian Great Lakes, specimens of Eurytemora have been reported as E. affinis since its invasion in the late 1950s. During an intensive collection of aquatic invertebrates for morphological and molecular identification in Lake Erie, several specimens of Eurytemora were collected. Analysis of their cytochrome oxidase I (COI) DNA barcodes identified them as closer to recently described E. carolleeae (Alekseev and Souissi 2011) than to E. affinis. Morphological analysis also identified them as E. carolleeae. Eurytemora from other areas of the Great Lakes and as west as the Missouri River, SD and east to Christina River, DE also keyed to E. carolleeae. Morphological analyses of archival specimens from 1962 and from all the Great Lakes were identified as E. carolleeae. Additionally, Eurytemora drawings in previous publications were reassessed to determine if the species was E. carolleeae. Additional morphological characters that might be useful in distinguishing the North American E. carolleeae from other taxa were also studied. We conclude that E. carolleeae is the correct name for the species of Eurytemora that has inhabited the Great Lakes since its invasion, as established by both morphological and COI sequence comparisons to reference keys and sequence databases in present and archival specimens.
Keywords: Invasive species, Taxonomy, Zooplankton, Genetics.

VERHAMME, E.M., DEPINTO, J.V., SCHLEA, D.A., REDDER, T.M., and BRATTON, J.F., LimnoTech, 501 Avis Dr, Ann Arbor, MI, 48108, USA. **Western Lake Erie Ecosystem Model: An operational model for the scientific and management community.**

Over the last five years LimnoTech has worked to develop the Western Lake Erie Ecosystem Model (WLEEM) to assist researchers and managers with answering complex questions regarding sediment and phosphorus fate and transport and connections to HABs in Western Lake Erie. This presentation will review recent applications of the model as part of (1) the Annex 4 modeling group for the Great Lakes Water Quality Agreement, (2) the 2014 CSMI year for Lake Erie to evaluate P cycling and internal load, and (3) a prediction and post audit of the severity of the2015 HABs bloom. 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. When updated on a periodic basis the model can help to monitor lake responses to watershed nutrient reduction efforts

and test new scientific hypothesis. 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: Ecosystem modeling, Harmful algal blooms, Phosphorus.*

VERHAMME, E.M.[1], KLUMP, J.V.[2], and STOW, C.A.[3], [1]LimnoTech, Ann Arbor, MI, USA; [2]University of Wisconsin-Milwaukee School of Freshwater Sciences, Milwaukee, WI, USA; [3]NOAA-GLERL, Ann Arbor, MI, USA. **Keeping the eye on the ball: Why our embayment systems deserve special attention.**

Although the major embayments of the Great Lakes represent only a fraction of the total area and volume of the Great Lakes system, they foster very diverse and productive ecosystems compared with their open water counterparts. While traditional long term monitoring programs have focused on open lake trends, recent work by regional research teams have begun to better understand the complex physical, chemical, biological systems in these fresh water estuaries. From a monitoring and management perspective the embayment systems represent a unique set of challenges. Most are dominated by a single large tributary, often times the largest tributary input within their respective Great Lake. Water quality criteria are often exceeded near the tributary mouth, but can turn oligotrophic further into the lake. Highly variable tributary flows lead to constantly changing water quality conditions, which are difficult to monitor and characterize on an average basis. This presentation will provide a historical perspective on research in these systems and help to set the stage for the session. *Keywords: Management, Coastal ecosystems.*

VISHA, A.[1], JAVED, A.[1], BHAVSAR, S.P.[2], and ARHONDITSIS, G.B.[1], [1]University of Toronto Scarborough, Department of Physical & Environmental Sciences, 1265 Military Trail, Toronto, ON, M1C 1A4, CANADA; [2]Ontario Ministry of Environment and Climate Change, 125 Resources Road, Toronto, ON, M9P 3V6, CANADA. **Total Mercury (THg) Trends Across Trophic Levels in the Canadian Great Lakes.**

Mercury is one of the most prevalent contaminants in the Great Lakes, and is of particular interest in regards to safe fish consumption. Recent studies have indicated that THg concentrations in Ontario water bodies are increasing. Safe fish consumption and human health will be affected substantially over the next few decades if the increasing THg trends continue. This study employs Dynamic Linear Models (DLMs) to examine temporal THg levels and rates of change from 1975-2013 with respect to fish food web dynamics from skinless boneless filet samples (SBF) obtained across all of the Canadian Great Lakes. We focused on fish species that are inclusive of both higher and lower trophic levels (Walleye, Lake Trout, Yellow Perch, Chinook Salmon, Brown Bullhead, Coho Salmon, Common Carp, Freshwater Drum). Across all Great Lakes, THg concentrations have significantly increased beginning in the mid 1990s. Lower predatory species, such as Brown Bullhead, Coho Salmon, Common Carp, and Freshwater Drum, exhibited more variable decadal trends in comparison to top predatory species. We attribute this increase in THg to the food web alterations induced from the introduction of non-native species, the new role of the sediments as a net contaminant source, and the potentially significant fluxes from the atmosphere. *Keywords: Consumption advisory, Trophic level, Dynamic linear modelling, Fish toxins, Mercury.*

VOUK, I.[1], BURCHER, R.S.[1], JOHNSTON, C.M.[2], and JENKINSON, R.W.[3], [1]National Research Council, 1200 Montreal Road, M-32, Ottawa, ON, K1A 0R6, CANADA; [2]United States Geological Survey, 331 Commerce Way, Pembroke, NH, 03275, USA; [3]International Joint Commission, 234 Laurier Avenue West, Ottawa, ON, K1P 6K6, USA. **Source and land-to-water delivery variables for a bi-national SPARROW model.**

The SPARROW model contributes insight to the transport and delivery of nutrients such as phosphorus and nitrogen from streams and rivers to downstream receiving waters. The model describes the role of anthropogenic activities and natural processes to water quality parameters in surface waters. Thus, inclusion of components impacting the receiving waterways stemming from urban and agricultural areas, as well as geological, hydrological and climatic processes is of great importance. The SPARROW model is best suited for large-scale watersheds where a variety and a large quantity of data are available. An area such as that encompassed by the bi-national mid-continental SPARROW model - including the Great Lakes - is a good example of a SPARROW application. The work required collaboration between differing levels of government (i.e. federal, provincial and state agencies). This presentation will focus on unique processing requirements essential to data harmonization across national and international borders. Spatially available data (land cover, soil classes, precipitation, temperature, etc.) as well as census and other quantitative data (agricultural practices, point sources, landscape slopes, etc.) will be discussed.
Keywords: Nutrients, Water quality modelling, Spatial distribution, Watersheds.

W

WAGNER, N.D., SIMPSON, A.J., and SIMPSON, M.J., Environmental NMR Centre and Department of Physical & Environmental Sciences University of Toronto, 1265 Military Trail, Toronto, ON, M1C 1A4, CANADA. **Metabolomic responses to sub-lethal contaminant exposure in neonate and adult *Daphnia*.**

Humans alter ecosystems through use of consumer products, and pharmaceuticals that act as contaminants entering lakes through runoff and waste water effluents. Traditional toxicological end points may underestimate the impacts of contaminants as lethal concentrations are often orders of magnitude higher than that found within lakes. While newer techniques examine the metabolic responses of sub-lethal contaminant exposure, there has been no direct comparison between different life stages of aquatic organisms. Here we test the hypothesis, *Daphnia magna* will have distinct metabolic changes to 3 different sub-lethal contaminant exposures caused by differences in the toxic mode of action and life-history. We measured the 1H NMR metabolomic profiles in Day 0 and 18 Daphnia exposed to 27% of the LC50 of atrazine, propranolol and PFOS for 48 hours. PCA revealed significant separation of contaminants from the control in both neonate and adults with the exception of atrazine in the neonate experiment. The percent change of targeted metabolites between the exposures and the controls often occurred in the same direction (increased or decreased) in both neonates and adults however the magnitude of change differed for some metabolites. These results indicate that neonates and adults respond uniquely to sub-lethal contaminant exposure. *Keywords: Bioindicators, Environmental contaminants, Macroinvertebrates.*

WALLACE, A.M. and BIASTOCH, R.G., Toronto Region Conservation Authority (TRCA), 5 Shoreham Drive, Toronto, ON, M3N 1S4, CANADA. **Detecting Responses in Benthic Invertebrate Communities to Increasing Stream Chloride in Toronto, Canada.**

Road salt use and stream chloride concentrations have increased in North American cities over the past few decades. We investigated changes in stream chloride concentrations in 2002 and 2012 in Toronto, Canada, and related chloride to corresponding changes in benthic macroinvertebrates in the same years. Median stream chloride concentrations in 2012 almost doubled the median concentration in 2002, despite the mild winter in 2012. The strong relationship between field conductivity and laboratory chloride concentrations (R^2=0.93) was used to model summer chloride values for 51 benthic macroinvertebrate (BMI) sampling sites in 2002 and 2012. BMI assemblage shifts with respect to chloride were investigated using conventional metrics and Threshold Indicator Taxa ANalysis (TITAN). Conventional metrics failed to give a coherent pattern of the change between the two time periods. TITAN results showed that the number of taxa sensitive to chloride decreased over the two time periods and the number of taxa tolerant to chloride increased. We identified a 2002 BMI community threshold range of approximately 50 to 90 mg/L of chloride, which is below the Canadian Water Quality Guideline of 120 mg/L for chronic exposure to chloride

suggesting that chloride may be having non-lethal effects on the BMI community.
Keywords: Water quality, Chloride, Urban watersheds, TITAN, Macroinvertebrates.

WALSH, M.G.[1], HOLDEN, J.P.[2], RIHA, M.[3], WEIDEL, B.C.[1], CONNERTON, M.J.[4], RUDSTAM, L.G.[5], DOKA, S.E.[6], and MILNE, S.[7], [1]USGS Great Lakes Science Center, LOBS, 17 Lake Street, Oswego, NY, 13126, USA; [2]Ontario Ministry of Natural Resources and Forestry, LOMU, 41 Hatchery Lane, Picton, ON, K0K2T0, CANADA; [3]Institute of Hydrobiology Fish EcologyUnit (FishEcU), Na Sadkach 7, Ceske Budejovice, 370 05, CZECH REPUBLIC; [4]New York State DEC, Lake Ontario Unit, 541 East Broadway, P.O. Box 292, Cape Vincent, NY, 13618, USA; [5]Cornell University, 211A Fernow Hall, Ithaca, NY, 14850, USA; [6]Fisheries and Oceans Canada, Burlington, ON, CANADA; [7]Milne Technologies, PO Box 237, Keene, ON, K0L2G0, CANADA. **Using Hydroacoustics to Investigate Patterns in Alewife Distribution in Lake Ontario.**

Given the importance of Alewife as the dominant forage fish in Lake Ontario, managers have emphasized the need to better understand their lakewide distribution and important population metrics. Disruptions to the forage base in Lakes Huron and Michigan have had drastic effects on salmonid fisheries. However, despite similarities between these systems and Lake Ontario, patterns in Alewife population metrics observed in Lakes Michigan and Huron are not apparent for Lake Ontario. Alewife age- and size-structure have remained constant, and fish condition is high despite concerns about epilimnetic zooplankton declines. We used hydroacoustics to evaluate several aspects of Alewife distribution during 2013-2015. Diel summer (July-September) and offshore seasonal (spring, summer, fall) distributions of alewife were studied in 2013. Diel patterns indicate that during the day alewife schools were found deeper in the water than during the night and partly merged with the deep chlorophyll layer (DCL). Seasonal distribution reflects movement patterns of alewife to nearshore areas to spawn during summer. We will also report some relevant results from 2015 regarding daytime distributions of alewife during the spring, and results of an experimental evaluation of the effects of vessel speed on noise and quality of acoustic data. *Keywords: Distribution patterns, Alewife, Hydroacoustics, Fisheries, Lake Ontario.*

WANG, H., URBAN, N.R., and ZHANG, H., Michigan Technological University, 1400 Townsend Drive, Houghton, MI, 49931, USA. **Mercury atmospheric deposition to and runoff from catchments in Michigan's Upper Peninsula.**

To fully understand lake sediment profiles of mercury or to use mass balance models to predict mercury methylation and bioaccumulation in lakes, mercury inputs from the catchment must be known. Several previous mercury mass balance models for lakes include an assumption that 20-25% of mercury entering the catchment from atmospheric deposition

will run off the catchments into the lake. Other studies have assumed identical rates for wet and dry atmospheric deposition, or identical rates of atmospheric deposition to the lake and the catchment, or other similar assumptions that impact the model results. The goal of this study is to re-examine the fraction of atmospheric deposition that enters a catchment and is mobilized into lakes. This study focus on the Upper Peninsula of Michigan because land cover and environmental conditions are relatively uniform across the region. This study gathered all relevant data (wet deposition, dry deposition, leaf litter rate, mercury concentrations in lakes and streams, accumulation rates in sediments) for the entire Upper Peninsula of Michigan. The data suggest that anywhere from 5% to 25% of atmospherically deposited mercury may be flushed out of catchments into lakes; the average is only about half of previous estimates. *Keywords: Deposition, Watersheds, Mercury.*

WÄNGBERG, S.A., ARNEBORG, L., and BROSTRÖM, G., Dept. Marine Sci., University of Gothenburg, Box 461, Gothenburg, SE-405 30, SWEDEN. **Phytoplankton and bacteria in Lake Vänern - biomass, production and dependence of physical factors.**

Lake Vänern is a large lake in central Sweden. It is divided into two major parts where most inflows, including nutrients, come with rivers to the eastern part while the outflow is in the western part. Production in the lake is dependent on the hydrography which is complicated with, in some parts, extensive archipelagos and rough topography. Within our project on Lake Vänern we are interested in a better understanding of the distribution of the microbial (bacteria and phytoplankton) biomass and production in time and space. This is needed for knowledge about the ecosystems in the lake today and for better forecasts following environmental, including climate, changes. For this, we combine measurement of hydrography, chemistry and biology with the aim to produce reliable three dimensional models. The project is in its initial stage. Here we present the aim and outline of the project and some first data. *Keywords: Hydrodynamic model, Bacterial production, Plankton, Nutrients, Biogeochemistry, Photosynthesis.*

WATKINS, J.M.[1], WARREN, G.J.[2], HOLECK, K.T.[1], and RUDSTAM, L.G.[1], [1]Cornell Biological Field Station, 900 Shackelton Pt Rd, Bridgeport, NY, 13030, USA; [2]US EPA GLNPO, 77 W Jackson Blvd, Chicago, IL, 60604, USA. **Nearshore Assessment of Lake Ontario South Shore Using Emerging Technologies.**

The nearshore habitat of the south shore of Lake Ontario was assessed using a Triaxus towed underwater vehicle from July 15-18, 2013 as part of the Ontario 2013 Cooperative Science and Monitoring Initiative (CSMI) efforts of the US EPA Great Lakes National Program Office (GLNPO). Deployed sensors (CTD, Fluoroprobe, Phytoflash, and

Laser Optical Plankton Counter) tracked water quality, phytoplankton, and zooplankton distributions on a west to east path along the coast at the 20 m contour from Burlington, Ontario to Chaumont Bay, NY. This path (undulating from near surface to 15 m depth) crossed plumes entering the lake from Hamilton Harbor, the Niagara River, and the Genesee River at Rochester, NY. Water chemistry and biological distributions are compared to station based nearshore monitoring conducted within the multiagency Lake Ontario US Biomonitoring Program. 2013 data is also compared to a similar towed package effort conducted in the last intensive survey of 2008 (Yurista et al. 2012). *Keywords: Lake Ontario, Phytoplankton, Zooplankton.*

WATSON, N.[1], HUMMEL, S.[1], JONAS, J.L.[2], STUDENT, J.J.[1], and PANGLE, K.L.[1], [1]Central Michigan University, Mount Pleasant, MI, USA; [2]Michigan Department of Natural Resources, Charlevoix, MI, USA. **Identification of Origins of Juvenile Steelhead Using Otolith Chemical Signatures.**

Lake Michigan Steelhead, Oncorhynchus mykiss, are a mix of hatchery and wild fish, the latter originating from different tributaries within the lake basin. This mixed population can complicate conservation and management due to unequal contributions from various stocks making it necessary to better understand their origins. We evaluated the use of otolith chemistry as an approach to identify the natal origin of Lake Michigan steelhead. Using LA-ICP-MS, we analyzed the otoliths of juvenile steelhead collected in 2013-2015 from 41 Michigan and Wisconsin tributaries. We found distinct chemical signatures occurring between fish from different streams and hatcheries that could be used to accurately predict their natal origins. The study included the analysis of calcium, the major cation in otolith carbonate, and the trace elements barium, copper, lead, magnesium, manganese, strontium, and zinc. Strontium was found to be the most important trace element for discrimination. Classification accuracies were found to be higher on a regional level versus the tributary level. Our results demonstrate an important utility for otolith chemistry and provide a framework for future studies to determine the natal origins of adult steelhead populations in Lake Michigan, thus benefiting the management of both steelhead and their natal habitats. *Keywords: Recruitment, Trout, Chemical analysis.*

WAZ, A.[1] and CREED, I.F.[2], [1]University of Western Ontario, Department of Geography, London, ON, N6A 3K7, CANADA; [2]University of Western Ontario, Department of Biology, London, ON, N6A 3K7, CANADA. **Automating the identification of altered wetlands.**

Wetlands are widely recognized for their potential to provide diverse ecosystem functions including water storage, nutrient retention and habitat for enhanced biodiversity. In areas of high wetland loss, wetland restoration is being pursued to restore ecosystem functions. While progress has been made in automating wetland identification using remote sensing, the identification of lost or altered wetlands remains a persistent challenge. Automated techniques to identify altered wetlands would provide a powerful tool to understand wetland change and identify potential sites for restoration. The curvature of the landscape, analyzed from Light Detection and Ranging (LiDAR) Digital Elevation Models, is a metric which shows particular promise in being able to identify wetlands altered through drainage ditches. This method is currently being developed to identify candidates for wetland restoration in the Nose Creek watershed, a subwatershed of Lake Winnipeg. *Keywords: Lake Winnipeg, Wetlands, GIS.*

WEINKE, A.D., KOOPMANS, D.J., and BIDDANDA, B.A., Annis Water Resources Institute - Grand Valley State University, 740 W. Shoreline Dr., Muskegon, MI, 49441, USA. **Time-series buoy observatory allows monitoring of unforeseen and difficult to track lake phenomena.**

Since 2011, the Muskegon Lake Observatory (MLO) has collected meteorological, biological, chemical, and physical data that has been used to examine lake processes on time-scales from minutes to years. Most notably, MLO alerted us to persistent lake-wide hypolimnetic hypoxia that had only been sporadically observed in the past with traditional seasonal monitoring. We also detected the previously unobserved phenomenon of intrusion of Lake Michigan water through the connecting channel into the lake hypolimnion, possibly providing a significant reprieve from summertime hypoxia, expanding fish habitat, and limiting internal nutrient loading. On short time-scales we can couple meteorological with chemical and physical data to help understand the influence of episodic weather events on the water column structure of the lake. On longer time-scales, we can examine drivers of the strength of stratification, the density and duration of algal blooms, and the severity of hypoxia. The ever-growing dataset reveals episodic events as well as persistent phenomena and allows us to investigate their causes and consequences on the lake ecosystem. Working in concert with traditional direct sampling and measurements, this lake observatory is expected to fundamentally advance our understanding how the lake and its connecting watershed work. *Keywords: Buoys, Hypoxia, Water quality, Blooms, Observing systems, Ecosystem Monitoring.*

WELLEN, C.C.[1], MOHAMED, M.N.[2], and VAN CAPPELLEN, P.[1], [1]Ecohydrology Research Group, Department of Earth and Environmental Sciences, University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L 3G1, CANADA; [2]Ontario Ministry of the Environment and Climate Change, 125 Resources Road, Toronto, ON, M9P 3V6, CANADA. **How much data is needed to robustly detect changes in water quality in agricultural watersheds?**

Despite the investment of significant resources in agricultural beneficial management practices (BMPs) designed to reduce the export of nutrients to the environment, there is little consensus on their watershed-scale effectiveness. Modelling studies often conclude that significant water quality benefits are achievable from BMP implementation, yet empirical work struggles to detect significant changes in water quality. This work adapts statistical power analysis methodologies to the case of change detection in stream water quality. Using data from a number of watersheds in the Great Lakes ranging in size from 1000 to 1,800,000 ha, this talk will show that detecting changes in watershed scale annual nutrient loads requires decades of data, even for large effect sizes such as the recommended binational 40% reduction in nutrient loads. Detecting changes in flow-weighted concentrations still requires significant amounts of data (~11 years). Subsampling approaches were used to reproduce common sampling regimes. Over long time scales, monthly sampling regimes required about 50% more time than daily sampling regimes to arrive at similar levels of statistical power, while weekly sampling required roughly the same length of time. Concrete guidelines for the design of sampling programs to detect watershed scale changes will be presented.
Keywords: Watersheds, Nutrients, Monitoring.

WELLS, D.J.[1], RUTHERFORD, E.S.[2], EPPEHIMER, D.E.[4], CAVALETTO, J.F.[2], LIEBIG, J.R.[2], VANDERPLOEG, H.A.[2], BUNNELL, D.B.[4], HÖÖK, T.O.[3], HUTTON, M.A.[3], COLLINGSWORTH, P.D.[3], ZISCHKE, M.T.[3], and CLARAMUNT, R.M.[5], [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; [3]Purdue University, 195 Marsteller Street, West Lafayette, IN, 47907, USA; [4]USGS, 1451 Green Rd, Ann Arbor, MI, 48105, USA; [5]Michigan Department of Natural Resources, 96 Grant Street, Charlevoix, MI, 49720, USA. **Thermocline Formation Timing Affects Lake Michigan Larval Fish Phenology and Recruitment Potential.**

Spatio-temporal match or mismatch of fish larvae with favorable environmental conditions and adequate prey biomass is hypothesized to cause variability in recruitment of fish populations. During 2015 CSMI, we sampled fish larvae, zooplankton, and physical variables monthly from April-September along a nearshore to offshore transect in southeast Lake Michigan before, during and after thermocline development. We extracted otoliths to age larvae, quantified larvae diets, and used bioenergetics models to estimate larvae

consumption rates. In 2015, thermocline development was later and temperatures were cooler than in 2010, when a large alewife year class was formed. Densities of alewife and bloater larvae in July from 2010-2015 were correlated with juvenile densities in USGS fall trawl surveys, suggesting year class strength is set by the larval stage. Early thermocline development may enhance alewife and bloater recruitment through its effects on timing of larvae hatch and growth rate. *Keywords: Lake Michigan, Thermocline, Recruitment, Bloater, Alewife.*

WELLS, M.G.[1], YANG, B.[1], BROWN, L.[2], and YOUNG, J.[3], [1]University of Toronto Scarborough, Toronto, ON, M1C1A4, CANADA; [2]University of Toronto Mississauga, Toronto, ON, L5L 1C6, CANADA; [3]Ontario Ministry of the Environment and Climate Change, Toronto, ON, M9P 3V6, CANADA. **Variations of temperature and dissolved oxygen during under-ice convection in lake Simcoe.**

High-frequency observations of thermal structure under the ice of a large lake reveal the presence of large (10-20 m) overturning convection cells, driven by solar heating. Two winters observations are used to quantify the under-ice mixing and dissolved oxygen dynamics. The most vigorous convection occurred near the end of winter, as the water surface layer started warming, with a gradually deepening of the mixed layer over time. This coincided with the prediction by the Canadian Lake Ice Model of when the ice cover began to melt and decrease in thickness. 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 revealed that very large scale mixing occurred beneath the ice; the mixed layer depth increased during the melting period, and mixing was most active during the day. *Keywords: Ice, Water currents, Lake Simcoe.*

WHEELOCK, B.A.[1], GEHRING, T.M.[1], UZARSKI, D.G.[1], NIEMI, G.J.[2], TOZER, D.C.[3], HOWE, R.W.[4], and NORMENT, C.J.[5], [1]Institute for Great Lakes Research, Department of Biology, Central Michigan University, Mt. Pleasant, MI, USA; [2]Natural Resources Research Institute, University of Minnesota - Duluth, Duluth, MN, USA; [3]Bird Studies Canada, Port Rowan, ON, CANADA; [4]Cofrin Center for Biodiversity, University of Wisconsin - Green Bay, Green Bay, WI, USA; [5]Department of Environmental Science and Biology, The College at Brockport, SUNY, Brockport, NY, USA. **Factors Affecting Current Distribution of Anurans in Great Lakes Coastal Wetlands.**

Great Lakes coastal wetlands are ecologically and economically vital to people living in or near the Great Lakes basin. Many ecosystem services such as ground water recharge, flood retention, carbon sequestration, filtration of pollutants, and providing habitat for numerous vertebrate, invertebrate, and plant species are carried out by coastal wetlands. In the Great Lakes basin as many as 50-95% of coastal wetlands have been lost to agriculture and development. Amphibians are an important part of wetland food webs and are indicators of wetland health. Populations of amphibians are declining worldwide due to habitat loss and degradation, disease, climate change, overexploitation, and the introduction of exotic species. The goal was to identify areas where anuran species were present, areas that have suitable habitat for each species, and environmental factors important for anuran species for use in Great Lakes coastal wetland restoration plans. Species presence data were collected from 2011-2015 throughout the entire Great Lakes basin as part of a Great Lakes coastal wetland monitoring program. These data and environmental GIS data were entered into MaxEnt and the results were mapped showing known and potential distributions of each anuran species. Wetland area and road density were dominant covariates for 8 of the 9 species. *Keywords: Spatial distribution, Amphibians, Coastal wetlands, Restoration.*

WHELAN, G., Michigan Department of Natural Resources - Fisheries Division, P.O. Box 30446, Lansing, MI, 48909, USA. **Who is next? Some thoughts on the likely next pathogen and fish health challenges for the Great Lake.**

Fisheries scientists do not understand disease dynamics and are rarely aware of fish health issues in wild fish until they become epizootic events. For example, the large shift in Lake Michigan Chinook Salmon mortality rates from bacterial kidney disease in the 1980s was not detected until 3-5 years after it began and it took another 3-5 years for basin-wide action to be fully implemented to control this pathogen. Thus, it is likely that the next wave of pathogens being expressed as disease will be detected in an epizootic that is an outgrowth of some ecosystem stressor. Who will the next group of "bad guys" be? Many potential aggressive pathogens that could be expressed as diseases including: BKD; VHS; LMBv; WD; flavobacterium diseases; and furunculosis. But who else may be on the horizon? Possibilities for the next big issue include: Asian tapeworm; a salmon herpesvirus such as EEDv/ISA; Heterosporis sp.; Nidoviruses; IHN; carp viruses; PKD; and a host of European viruses/bacteria. Most invasion pathways can be controlled but the large cargo and angler pathways are vexing management problems. While risk assessment models are available to guide fisheries management decisions, actual predictive models for fish pathogens are not available and filling this gap would be helpful for future prevention and control efforts. *Keywords: Pathogens, Fish health.*

WILCOX, E.M., NEW Water, 2231 N. Quincy Street, Green Bay, WI, 54302, USA. **Utilities Without Borders.**

The sole purpose of a wastewater treatment utility has traditionally been to treat wastewater and return clean water back to our environment. The Green Bay Metropolitan

Sewerage District, now NEW Water, has gone beyond this concept. 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 samples, monitoring trend 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. Green Bay and the Fox River have a long history of industry and urban influence. While water quality has improved under the Clean Water Act, large scale clean-up projects, and local efforts; serious water quality problems remain. NEW Water has again gone beyond its traditional role to work in the surrounding watershed in an effort to reduce soil and nutrient runoff, meet future permit compliance, and take meaningful steps to improve local water quality issues. *Keywords: Green Bay, Monitoring, Water quality.*

WILSON, M.C.[1], SHORE, J.A.[2], RAO, Y.R.[3], and BOEGMAN, L.[1], [1]Queen's University, Kingston, ON, K7K1K6, CANADA; [2]Royal Military College, Kingston, ON, CANADA; [3]Canada Centre for Inland Waters, Burlington, ON, CANADA. **Optimization of vertical mixing parameterizations using GOTM in FVCOM.**

Three-dimensional numerical models have difficulty accurately reproducing the seasonal temperature structure in large lakes such as Lake Ontario. Various models have been applied to Lake Ontario and other lakes but the simulated seasonal thermoclines are too diffuse. Sub-grid parameterizations must be employed on the coarse grids required in large lakes for turbulence closure, to account for small scale physical processes such as vertical mixing of heat. Unfortunately, simulated temperatures in the Finite Volume Coastal Ocean Model (FVCOM) have been shown to have greater errors than other three-dimensional models applied to similar problems. Modelled temperatures are too warm in the hypolimnion, and too cold in the epilimnion. The General Ocean Turbulence Model (GOTM) is now included in newer versions of FVCOM which offers an opportunity to test multiple methods for calculating turbulent kinetic energy and length-scale parameterizations in order to assess their relative efficacy at simulating the vertical mixing of heat on a seasonal timescale. Results have indicated that certain length-scale methods are less suitable for FVCOM while others are more robust and offer further opportunity to tune model parameters toward the goal of an accurately reproduced seasonal thermocline.
Keywords: Lake Ontario, Hydrodynamic model, Model testing.

WINTER, C.L., THOMPSON, M.A., SIWULA, P.J., and ARMSTRONG, M.R., UW-Milwaukee, School of Freshwater Sciences, Milwaukee, WI, 53204, USA. **Fecal Bacterial Contamination Accompanying Tourism Growth.**

Inadequate sewage infrastructure threatens the health of Mexico's second largest freshwater lake, Laguna Bacalar. As development and rapid tourism growth increases. A combination of fecal coliform indicator bacteria, E. coli and fluorometer metrics were used to determine presence of human sewage. Samples were collected offshore, near sites of high usage, such as boat landings and docks, hotels and conference centers. Sample sites were also chosen in relation to a proposed research field station that would serve as an educational center for scientist, institutions and locals to aid in preserving this unique ecosystem. Results showed that nearly all samples collected nearshore had high concentrations of coliform present. This indicates the possibility of sewage presence along the lakeshore. Human sewage contamination not only threatens the lake's ecosystem but also public health. The results of this study can be used to determine possible contamination sources that are targeted during remediation efforts. Evidence of human fecal contamination can also help direct local municipalities to make appropriate actions in order to avoid irreversible negative impacts to the lake. *Keywords: Pollution sources, Human health, Water quality.*

WONG, I.[1], LEON, L.[1], FONG, P.[1], LIU, Y.[2], and YANG, W.[2], [1]Environment and Climate Change Canada, 867 Lakeshore Road, Burlington, ON, L7S1A1, CANADA; [2]University of Guelph, 50 Stone Road East, Guelph, ON, N1G2W1, CANADA. **Optimization of Beneficial Management Practice in the SWAT Model for Grand River Watershed.**

The Great Lakes Nutrient Initiative (GLNI) is a priority program of Environment and Climate Change Canada. Within its framework, this study focuses on developing strategies for beneficial management practices (BMP) in the Grand River (GR) watershed to assist in establishing nutrient objectives for the east basin of Lake Erie by reducing phosphorus loads at the watershed outlet. Four suitable BMPs for the GR watershed were chosen after consultation with domain experts: (1) vegetative filter strips, (2) nutrient management, (3) wetland restoration, and (4) cover crops. Several multiple BMPs scenarios were developed using the SWAT (Soil and Water Assessment Tool) model. Since many scenarios with different combinations of BMPs can achieve the same target load objective, there is a need to find an optimal set of BMPs for a given load target. An optimization process using a genetic algorithm technique was applied to generate optimized scenarios for TP (Total Phosphorus) and SRP (Soluble Reactive Phosphorus) objectives. Scenario optimization was applied to evaluate various cases for TP load reduction and increase during the spring period to support the setting of Cladophora targets. Results showed that the optimized scenario for 40% TP reduction target at the outlet predicted lower mineral P loads than non-optimized scenario. *Keywords: Nutrients, Beneficial management practice, Grand River, Modeling.*

WOOD, N.J., GEHRING, T.M., and UZARSKI, D.G., Central Michigan University, Mount Pleasant, USA. **The invasive mute swan impacts on submerged aquatic vegetation in Michigan's coastal wetlands.**

Mute swans (*Cygnus olor*) are an invasive spices that have been introduced multiple times to North America (Ciaranca et al., 1997; Allin et al., 1987). Since those introductions, the mute swan population has steadily increased at a rate of 10-18% annually, resulting in a Michigan population estimated at 15,500 individuals in 2010 (Petrie & Francis, 2003; MDNR, 2012). Mute swans are tremendous consumers of submerged aquatic vegetation (SAV), their preferred food (Allin & Husband, 2003). A reduction in SAV impacts food resources for other bird species and diminishes habitat resources for small fish and invertebrates (SFI). SAV and SFI sampling occurred in September 2012 and 2013 in the drowned river mouth lakes along the eastern shore of Lake Michigan. Transects were drawn through each SAV bed and a throw trap was placed at three different depth intervals. The SAV in the trap was removed, identified, and a dry weight of each species was obtained. Abiotic data was also collected from each SAV bed. Lakes with high mute swan populations showed reductions in SAV height, dry weight, and DO % when compared to low mute swan populations. An inverse relationship with annual mute swan population changes and SAV variables emerged. These analyses show that mute swans may be negatively impacting the coastal wetlands in Michigan. *Keywords: Coastal wetlands, Avian ecology, Invasive species.*

WRIGHT, D.M. and POSSELT, D.J., University of Michigan, Ann Arbor, MI, 48103, USA. **The Influence of Lake Surface Temperatures on a Cold Frontal Passage Over Lake Superior.**

The role of the Laurentian Great Lakes in modifying the climate of the upper Midwest and southern Canada is relatively well understood (Scott and Huff 1996), but the direct effect of differences between lake surface and air temperature on the duration, intensity, and placement of precipitation across the region is still unknown, especially in the warm season. With lake surface temperatures projected to warm in a future climate (Trumpickas et al. 2009), it is important to understand how these changes influence the atmospheric circulations and associated precipitation in the Great Lakes region. In this case study, a cold frontal passage over Lake Superior during an early July event is explored through a series of high-resolution (2 km horizontal grid spacing) Weather Research and Forecasting Model (WRF) simulations, each with varying lake surface temperatures.

Increases in lake surface temperature, on the order of 8 Kelvin, produce a 25% increase in low-level water vapor directly over and near the lake. This increase in water vapor results in a minimal increase in overall precipitation across the region (<10%), with a majority of this increase occurring before the front reaches the lake. *Keywords: Atmosphere-lake interaction, Modeling, Atmospheric circulation, Model studies, Lake Superior, Climate change.*

WU, M.Z., O'CARROLL, D.M., VOGEL, L.J., and ROBINSON, L.J., Department of Civil and Environmental Engineering, Western University, London, ON, CANADA. **Accumulation and Distribution of Fecal Indicator Bacteria near the Shoreline at Freshwater Beaches.**

Beach sand can act as a reservoir for fecal contaminants with fecal indicator bacteria (FIB) often orders of magnitude higher than in adjacent surface waters. Elevated FIB (Escherichia coli (E. coli), enterococci (ENT)) concentrations can lead to beach water quality advisories. This study used field measurements and numerical modelling to investigate the physical processes controlling the accumulation and distribution of FIB in beach sand with specific focus on the effects of low energy, non-erosive waves. E. coli and ENT were measured in the pore water across two beaches on Lake Huron and Lake Ontario with samples collected up to 2.3 m depth below the water table. A numerical model simulating wave-induced groundwater flow coupled with microbial transport (using colloid filtration theory) reproduced the overall FIB distributions at the two beaches. The model was then applied to assess the impact of various factors including beach slope, sediment type and wave height on FIB accumulation. The infiltration zone width, average infiltration velocity and infiltration rate were shown to ultimately control the amount and spatial distribution of FIB in the sand. Study findings are important in identifying factors controlling the accumulation of FIB in beach sand at freshwater beaches and thus ultimately reducing health risk at beaches. *Keywords: Bacteria, Fecal indicators, Beaches.*

X

XAYKONGSA, A.[1], MARSHALL, S.N.[1], MCDONALD, C.M.[1], SCAIFE, L.[1], and JOHNSTON, J.W.[2], [1]Department of Earth and Environmental Sciences, Earth Sciences Museum, University of Waterloo, 200 University Ave West, Waterloo, ON, N2L3G1, CANADA; [2]Department of Earth and Environmental Sciences and Water Institute, University of Waterloo, 200 University Ave West, Waterloo, ON, N2L3G1, CANADA. **Using geologic knowledge to explain patterns and variations in 3D physical models of the Great Lakes.**

To help students and community members comprehend the dimensions, elevations, and configuration of the lake basins and connecting rivers that comprise the Laurentian Great Lakes (LGL), a basic model of plastic containers, pipe cleaners and blocks was produced. This simple yet versatile model was able to contextualize personal experiences and spur discussions of local to global significance of the LGL. A rigorous compilation of data led to the development of the first complex 3D Physical Model (FDM-plastic, CNC-wood, foam) of the LGL to further show their complexities in the natural setting. Although visually and tactically stimulating, observers have sought deeper understanding of the patterns and variations presented by this model. Thus, we work towards implementing simple yet effective approaches to connect the present to the past, and surface to subsurface. The LGL is a product of its past, where numerous events in history have contributed to what exists today; this includes evidence of former tectonic plate boundaries, internal flexure of the continent to form large sedimentary basins, ancient river systems, and a massive continental ice sheet. Surface features as seen today can be explained by certain compositions of rock and sediment, their structure, and the processes that contributed to their formation or modification. *Keywords: Great Lakes basin, Geology, Education, Modeling.*

XIAO, C.[1] and LOFGREN, B.M.[2], [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. **Projected Hydroclimatological Responses of the Great Lakes to Global Warming.**

As the largest group of fresh water on Earth, the Laurentian Great Lakes have significant influence on regional climate through their unique physical features. Due to the limited spatial resolution of general circulation models (GCMs), the Great Lakes are geometrically ignored in GCMs. Thus, the technique of dynamical downscaling serves as a feasible solution. The Weather Research and Forecasting model (WRF) with an updated lake scheme is employed to downscale from a GCM with future scenarios. Our results show that the WRF-Lake model, with a fine horizontal resolution and a realistic lake representation, improves the hydroclimatology simulation in terms of lake surface temperature (LST), precipitation, and ice coverage. Those improvements suggest that better resolution of the lakes and the mesoscale process of lake-atmosphere interaction are crucial to understanding the climate in the Great Lakes region. The diminishing of lake ice and rising of water levels, accompanying the LST increase, should be concerned in the presumed warming climate. Further comparisons of future projections between high and moderate emissions demonstrate that the Great Lake are very sensitive to the above atmosphere, especially for shallow lakes, but are also likely to mitigate the global trend because of their large thermal capacities. *Keywords: Climate change, Modeling, Air-water interfaces.*

XU, J.[1], ZHANG, A.[1], ANDERSON, E.J.[2], LANG, G.A.[2], and KELLEY, J.G.W.[3], [1]NOAA/NOS/CO-OPS, Silver Spring, MD, USA; [2]NOAA/OAR/GLERL, Ann Arbor, MI, USA; [3]NOAA/NOS/OCS, Durham, USA. **Upgrading NOAA's Great Lakes Operational Forecast System.**

In collaboration with NOAA's Great Lakes Environmental Research Laboratory (GLERL), the National Ocean Service (NOS) is upgrading the existing Great Lakes Operational Forecast System (GLOFS) to provide improved forecast guidance of water level, currents and water temperature. The first upgraded system is the Lake Erie Operational Forecast System (LEOFS), which is scheduled to become operational in March, 2016. The upgraded Lake Michigan and Huron Operational Forecast System (LMHOFS) is currently in the development stage and is presently scheduled to transition to operations in FY2018. The upgraded systems use the Finite Volume Community Ocean Model (FVCOM) as its core 3-D ocean circulation model. Higher horizontal and vertical resolutions and extended forecast horizons from 60 hours to 120 hours are the major improvements. An overview of the configuration of the upgraded LEOFS model nowcast and forecast performance, the plan for the upgraded LMHOFS and future improvements planned for the systems, such as ice forecasting, are described. *Keywords: Hydrodynamic model, Lake model, Ecosystem forecasting.*

XU, M.[1], LIU, H.[1], BECK, R.[1], WU, B.[2], LIOU, L.[3], LEKKI, J.[3], TERRI, B.[4], YU, B.[2], LIU, M.[2], EMERY, E.[5], and REIF, M.[5], [1]Department of Geography, University of Cincinnati, Cincinnati, OH, 45221, USA; [2]School of Geographic Sciences, East China Normal University, Shanghai, 200241, CHINA; [3]NASA Glenn Research Center, Cleveland, OH, 44135, USA; [4]AmericaView's Water Quality/Quantity/Utility Working Group, Kirtland, OH, 44094, USA; [5]Water Management Division, U.S. Army Corps of Engineers, Great Lakes & Ohio River Division, Cincinnati, OH, 45202, USA. **Regionally and Locally Adaptive Models for Retrieving Chlorophyll Concentration in Inland Lakes.**

Optical multispectral and hyperspectral images have been used to derive chlorophyll-a concentration as the proxy for algal bloom distribution in inland waters. The common practice of previous studies has been to calibrate a single band arithmetic model (global model) for the entire study area. The performance of a global empirical model is limited for optically complex inland waters. It often results in overestimates in some regions and underestimates in other regions. To address the inadequacy of the global model, this paper presents regionally or locally adaptive models to better estimate chlorophyll concentration.

For our case study areas, Harsha Lake in Ohio and Taylorsville Lake in Kentucky, coincident in situ chlorophyll measurements have been densely sampled with a YSI Sonde during the airborne hyperspectral flights. The hyperspectral imagery has been atmospherically corrected using ENVI FLAASH software and georeferenced with a set of differential GPS measured ground control points. We implement and evaluate a number of two-band and three-band arithmetic algorithms, including CI, NDCI, MCI, SABI, FLH and OC3m. We demonstrate that regionally- and locally-adaptive models can improve chlorophyll-a estimate accuracy for complex inland lakes respectively by 16% and 25%,in comparison with the single global empirical model. *Keywords: Water quality, Chlorophyll concentration, Algae, Hyperspectral imagery, Remote sensing, Regionally and locally adaptive models.*

XU, W.[1], COLLINGSWORTH, P.D.[2], MINSKER, B.S.[1], KRAUS, R.T.[3], and WARREN, G.J.[2], [1]University of Illinois at Urbana-Champaign, Urbana, IL, USA; [2]U.S. Environmental Protection Agency, Great Lakes National Program Office, Chicago, IL, USA; [3]U.S. Geological Survey - Great Lakes Science Center, Ann Arbor, MI, USA. **Spatio-temporal Kriging Analysis of Lake Bottom Dissolved Oxygen in the Central Basin of Lake Erie.**

Seasonal hypoxia (dissolved oxygen (DO) concentration lower than 2mg/L) is a major water quality issue in Lake Erie. To better understand seasonal hypoxia, the US EPA, the USGS and Illinois-Indiana Sea Grant deployed a network of temperature and dissolved oxygen loggers in central Lake Erie during the summers of 2014 and 2015. The logger network continuously measures DO concentration and temperature every 10 minutes. With the high-resolution logger data in 2014 and 2015, we fit a spatio-temporal variogram model based on the daily averaged DO. The variogram model is then used to produce a spatio-temporal kriging interpolation to estimate the DO concentrations spatially and temporally in the central basin. Our initial results show that seasonal hypoxia develops spatially from nearshore to offshore and progresses from from south west to north east throughout the summer. The temporal interpolation at loggers' locations also reveal some unusual patterns where the original 10-minute sampling interval DO data lie beyond the interpolation variance, indicating they have statistically large variance. *Keywords: GIS, Decision making, Lake Erie.*

Y

YANG, J., JIANG, T., and LIU, H., Freshwater Fisheries Research Center, Chinese Academy of Fishery Sciences, Wuxi, 214081, CHINA. **Spawning Site Location of Commercial Anadromous *Coilia nasus* in the Poyang Lake, China.**

Estuarine tapertail anchovy *Coilia nasus* is a highly valued anadromous species in the Yangtze River, China. For resource conservation, national and provincial governments manage its fishery by limiting fishing periods and restricting boat numbers. Unfortunately, the tendency of population degradation is still progressing. This situation led us to investigate its spawning sites, as conservation of the sites and assurance of sustainable recruitment will be much more important than merely saving commercial-sized fish. In 2014, we collected highly mature female *C. nasus* with stage IV and V spawning stage gonads in the water site around Xingzi County, in the Poyang Lake, which connects with the middle reach of the Yangtze River. In 2015, highly mature females with both stage IV and V gonads, and males at spent stage VI, were collected in the same location. Moreover, all of these fish were confirmed as anadromous *C. nasus* by otolith microchemical elemental fingerprints detected with EPMA and LA-ICPMS. The above evidence firstly suggests a spawning site exists in this location. However, a huge dam is proposed to be built near this location, and, the area is suffering heavy sand mining and overfishing. Corresponding protective strategies are urgently needed against these potential anthropogenic impacts. *Keywords: Fish management, Habitats, Fish.*

YANOS, C.L.[1], QIAN, S.S.[1], MAYER, C.M.[2], ROGERS, M.W.[3], and KANE, D.D.[4], [1]University of Toledo, 2801 W. Bancroft, Toledo, OH, 43606, USA; [2]University of Toledo Department of Environmental Sciences and Lake Erie Center, Toledo, OH, 43606, USA; [3]US Geological Survey, Tennessee Cooperative Fishery Research Unit, Tennessee Tech University, Cookeville, TN, 38505, USA; [4]Defiance College, 701 N. Clinton St., Defiance, OH, 43512, USA. **Evaluating Importance of Nutrient and Productivity Gradients on Lake Erie Fish-Community Structure.**

Nutrient gradients drive productivity gradients in Lake Erie. This study was designed to understand how productivity affects energy flow to fish and resulting fish-community structure. Water quality, zooplankton, benthos, and fish data were collected across several gradients in 2014; west to east, shallow to deep, and seasonally. We used classification and regression trees (CARTs) to determine which factors most influence total fish biomass and percent percid biomass (an indicator of desirable fish community). Region explains the majority of variance in total biomass whereas benthic and pelagic foodweb structure explains the most variance in percent percid biomass. Specifically, when the Maumee River plume is separated from the other regions variability in total fish biomass decreases by 51%. In the Maumee River plume depth is the most important factor while total phosphorus is the most important factor in all other regions. In contrast, total benthic followed by total zooplankton biomass are the most important factors influencing percent percid biomass, however together they explain only a relatively small amount of variance in percent percid biomass. Therefore overall productivity strongly influences total fish biomass but foodweb factors such as availability of benthic and pelagic food weakly affect fish species composition. *Keywords: Food chains, Lake Erie, Mathematical models.*

YONGABO, Y.P.[1], NYINAWAMWIZA, N.L.[1], and DESCY, J.P.[2], [1]University of Rwanda-College of Agriculture, Animal Sciences and Veterinary Medicine, Musanze, NP, 210, RWANDA; [2]University of Namur, Namur, BELGIUM. **Lake Kivu Fish Stock and its Sustainable Exploitation.**

Conducted researches showed the Lake Kivu ichthyologic fauna however its exploitation and fish catches variation in basins and seasons is not well understood by both researchers and lake managers. This study aimed at identifying the most targeted fish species and understanding fish catches spatial and temporal variations for a sustainable fisheries management in Lake Kivu. To achieve this, fisheries statistics were collected for 27 months from October , 2011 to December 2013. Data were recorded on daily basis across 59 fishing sites in 5 fishing zones of the lake. Our results showed that among 31 fish species only 5 species are targeted with the dominance of Limnotrissa miodon. Total catches showed a substantial temporal variation with high catches in the rainy period of April to June and the period following the fishing break ,January to March with a monthly average of 63.220t. CPUE didn't vary much except the closer periods to the fishing break with an average of 31.638 kg d-1. Both total catches and CPUE showed variations across basins with high catches in the southern part. Total catch was generally higher in 2013 than in 2011 and 2012, the same has been observed for the CPUE. *Keywords: Fisheries, Spatial distribution, Fish.*

YOUNG, J.[1], PALMER, M.E.[1], WINTER, J.G.[1], YAN, N.D.[2], KELLY, N.E.[2], LA ROSE, J.K.L.[3], and TUDORANCEA, C.[4], [1]Ontario Ministry of the Environment and Climate Change, 125 Resources Road, Toronto, ON, M9P 3V6, CANADA; [2]York University, 4900 Keele St., Toronto, ON, M3J 1P3, CANADA; [3]Ontario Ministry of Natural Resources and Forestry, 26465 York Rd 18, Sutton West, ON, L0E 1R0, CANADA; [4]Aquatic Bio-Services, 463 Doon South Drive, Kitchener, ON, N2P 2T6, CANADA. **The Zooplankton Community of Lake Simcoe: Indicators of the Effects of Multiple Stressors.**

Lake Simcoe has experienced many changes over the past decades, including invasive species introductions, fluctuations in fish species abundance, and shifts in temperature linked to climate change. Zooplankton, small crustaceans that form the middle of the pelagic food web, are excellent indicators of these changes and of aquatic ecosystem health. To determine what stressors have affected this important indicator, we analyzed the annual ice-free size and abundance of zooplankton species from 1986-2012 at three lake stations. Many changes were observed within the zooplankton community over the past 27 years that were similar across the lake, and were driven by bottom-up, top-down and climate related factors. The greatest changes in the zooplankton community appeared to be driven by the establishment of the invasive zooplankton, *Bythotrephes longimanus*, and climate related changes, such as increases in lake temperature and dissolved organic carbon concentrations. The implications of these drivers on changes to the zooplankton and other aquatic communities will be discussed further in this presentation. *Keywords: Lake Simcoe, Zooplankton, Ecosystem health.*

YU, A.W.[1], MOUW, C.B.[1], MOORE, T.S.[2], TWARDOWSKI, M.S.[3], SULLIVAN, J.M.[3], BARNETT, A.B.[1], and STOCKLEY, N.[3], [1]Michigan Technological University, Houghton, MI, USA; [2]University of New Hampshire, Durham, NH, USA; [3]Harbor Branch Oceanographic Institute, Fort Pierce, FL, USA. **Assessing the Spatial Distribution & Physical Drivers of Cyanobacterial Blooms 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 influence from these ecological and physical drivers on bloom distribution and water characteristics are not well understood. Here we merge satellite imagery with continuous in water measurements (recorded in the summers of 2013 and 2014 by a Land/Ocean Biogeochemical Observatory (LOBO) buoy), in situ field samples, meteorological observations, and river flow data to further elucidate spatial and temporal patterns of HABs. Specifically, we aim to better understand the impact the Detroit River has on bloom distributions within the basin. The data may reveal riverine influence on bloom dispersal and mixing providing further insight into the drivers of bloom variability. Additionally, the results from this project will help assist environmental monitoring programs to understand bloom movement, distribution, and initiation. *Keywords: Harmful algal blooms, Lake Erie, Spatial distribution.*

Z

ZASTEPA, A., WATSON, S.B., STALEY, Z., and EDGE, T.A., Environment and Climate Change Canada, 867 Lakeshore Road, Burlington, ON, L7S 1A1, CANADA. **Microbial Water Quality and Harmful Algal Bloom Risk Management in Hamilton Harbour and Beaches.**

Cyanobacteria harmful algal blooms (cHABs) threaten drinking- and recreational water aesthetics and safety and are a major cause of beach postings and closures. Some cHABs produce toxins, which are both accumulated in the cells and persist in water for several weeks after release and bloom decay. Beach monitoring and management for bacteria is well established across much of Canada and the US, but there are few comparable programmes for cHABs, despite recreational guidelines for safe exposure levels established in many jurisdictions (10-20 µg/L microcystin-LR). Furthermore, while aggravated bacterial contamination has been associated with attached algae, to date this link has not been evaluated for cHABs. We focussed on two public waterfronts in Hamilton Harbour (Lake Ontario) prone to beach closures caused by bacteria and cHABs to test seasonal relationships among water quality (e.g. nutrients), cHABs, toxins and fecal indicator bacteria (e.g. E.coli). We evaluated intra- and inter-site variability between May-November 2015 to assess optimum sampling strategy for beach monitoring, high risk sites (e.g. as a result of windblown scums), potential shoreline or offshore origins of bacteria and cHABs, and the implications of incorporating a cHAB beach bloom risk management programme and a bacterial beach monitoring programme. *Keywords: Harmful algal blooms, Risk management, Hamilton Harbour, Recreational waters, Water quality, Cyanotoxins.*

ZASTEPA, A.[1], WATSON, S.B.[1], and BOYER, G.L.[2], [1]Environment and Climate Change Canada, 867 Lakeshore Road, Burlington, ON, L7S 1A1, CANADA; [2]State University of New York, College of Environmental Science and Forestry, Syracuse, NY, USA. **Do nitrogen forms influence microcystin variant composition in Lake Erie and Ontario surface waters?**

Evidence suggests that the supply and chemistry of total dissolved nitrogen (TDN) influences the growth, dominance, and toxicity of harmful cyanobacterial blooms (cHABs). This has significant implications for the risk to human and animal health, provision of safe drinking water, and the long-term management of cHABs based on nutrient controls. The clinical toxicity of a water sample due to cyanotoxins depends on the class and variants of toxins present (e.g. the > 90 microcystin (MC) variants can range in toxicity >20-fold). Furthermore, their persistence and susceptibility to water treatment also vary. Research shows that cyanobacteria have an assimilatory preference for ammonium (NH4) followed by

nitrate (NO3), and then dissolved organic N, while total MC cell quota is stimulated by TDN. However, to date there is no consensus on how these different forms of N influence cHAB toxin production and toxicity. We tested this question by measuring the production of common cyanotoxins and their variants in response to enrichment with NH4, NO3 and urea, using both field observations and experimentation during 2014 and 2015 summer cruises in Lakes Erie and Ontario at sites where cHABs are a major issue. *Keywords: Harmful algal blooms, Water quality, Environmental effects.*

ZHANG, F.[1], REID, K.B.[2], and NUDDS, T.D.[1], [1]University of Guelph, Guelph, ON, CANADA; [2]Ontario Commercial Fisheries Association, Blenheim, ON, CANADA. **Non-stationary structure of fishery models: time-varying effects of ecological processes on fish recruitment.**

Non-stationary population processes are speculated to be caused by changes in external ecological processes, and incorporating ecological processes into fishery models is proposed as an approach to reduce model parameter non-stationarity. We hypothesized that another kind of non-stationarity may exist, such that the relative effects of multiple ecological processes change over time, leading to model structure non-stationarity. To test this hypothesis, we used biotic and abiotic data from the western basin of Lake Erie between 1999 and 2013 to model the relative effects of multiple ecological processes on yellow perch (*Perca flavescens*) recruitment. Results indicated that the relative importance of reproduction, bottom-up, top-down and physical environment effects on recruitment varied over time, as did the best performing recruitment model structure. Therefore, not only model parameterization, but also the selection/determination of model structure, and/or the weighting of multiple models in model averaging, may need to be adaptively iterated to better inform fisheries management in a non-stationary world. *Keywords: Fish populations, Recruitment dynamic, Lake Erie, Yellow perch.*

ZHANG, R.Y., WANG, L.Y., and CHEN, J.A., State Key Laboratory of Environmental Geochemistry, Institute of Geochemistry, Guiyang, 550081, CHINA. **Phosphorus speciation in surface sediments of a Chinese hypertrophic lake.**

Phosphorus (P) species in surface sediments from a shallow hypertrophic lake, Lake Dianchi, China, were investigated by P fractionation and 31P nuclear magnetic resonance (NMR) spectroscopy during a regional algal bloom, and their potential contributions to the overlying water were also evaluated. Labile fractions of P extracted by NH4Cl, bicarbonate dithionite and NaOH ranged from 340.6 to 1725.8 mg kg-1, accounting for 20.5%-67.2% of total P. 31P NMR Results showed that ortho-P and monoester-P were the most abundant P components, followed by diester-P and pyro-P. Spatial distribution of the sum of ortho-P, diester-P and pyro-P detected by 31P NMR corresponded well with the labile P concentration determined by fractionation. Both exhibited a significant positive correlation with total P in the water column, suggesting that internal loading may be an important source of P to the lake ecosystem. Biogenic P other than ortho-P may contribute to phytoplankton growth, with the relative proportion of 4.4%-18.7%. The release of labile P fractions fueled algal bloom, and the decay of organic matter following bloom events consumed oxygen and elevated pH value, thus this codependence might lead to in a vicious cycle. *Keywords: Eutrophication, Phosphorus, Sediment load.*

ZHANG, T.Q. and TAN, C.S., Harrow Research & Development Center, Agriculture $ Agri-Food Canada, 2585 County Rd. 20 E., Harrow, ON, N0R 1G0, CANADA. **Mitigating Phosphorus Loss from Agricultural Lands: Progresses and Perspectives.**

Agricultural lands have been deemed the primary non-point source of phosphorus (P) pollution causing the increased severity in toxic and nuisance algal blooms in the Great Lakes, particularly Lake Erie, over the past two decades. Pathways of P loss include surface runoff and erosion and subsurface tile drainage, both of which are ultimately driven by management practices, although they are a function of soil source (e.g. soil P status) and transport (e.g. hydrological conductivity) factors. Efforts have been made to develop beneficial management practices (BMP) to mitigate soil P loss, while sustaining crop productivity, including P-based manure addition, crop rotation, buffer strip, wetland system, conservation tillage, cover crop, and use of soil legacy P. For instance, use of legacy P in high-P soils can reduce P loss by 40%, while identical crop yields are produced, relative to P addition. However, benefits of the BMPs are often found process-specific, or temporally and/or spatially limited. Such as, conventional tillage may increase dissolved P and subsurface total P loss, while it reduces particular P loss through surface processes. This presentation will review both advantages and drawbacks of the key BMPs that are currently available, with the implication for water quality impacts and future research needs discussed. *Keywords: Phosphorus, Agriculture, Management, Runoff, Lake Erie, Tile drainage.*

ZHENG, Y. and MANDRAK, N.E., University of Toronto Scarborough, 1265 Military Trail, Toronto, ON, M1C 1A4, CANADA. **Title: Effects of Multiple Stressors on Brook Trout Populations in the Greater Toronto Area.**

Brook Trout (*Salvelinus fontinalis*) has been in decline in the Greater Toronto Area (GTA) since the 1800s due to multiple stressors. As a coldwater species, it is particularly sensitive to rising water temperatures due to land-use change and climate change. To assess stress levels in Brook Trout as a result of rising water temperatures, we will measure the response of different indicators of stress to various temperature treatments. By understanding the base levels of stress markers, such as cortisol and heat shock proteins (HSPs), and how they respond to temperature, these markers may be used in the future as measures of heat stress levels. Novel non-invasive sampling methods, such as cortisol in fish scales and HSPs in fin clippings, will be measured in various water temperatures in both the lab and in wild populations and compared to conventional sampling methods, such as plasma cortisol and HSP in tissue samples to confirm their accuracy. We will also measure and compare these levels in related invasive species to determine if they are more tolerant of thermal stress. *Keywords: Heat stress, Invasive species, Indicators.*

ZHONG, Y.[1], VAVRUS, S.J.[2], and NOTARO, M.[2], [1]Space Science and Engineering Center (SSEC), University of Wisconsin-Madison, Madison, WI, 53706, USA; [2]The Nelson Institute Center for Climatic Research, University of Wisconsin-Madison, Madison, WI, 53706, USA. **Attributing the Heterogeneous Warming of the Laurentian Great Lakes to Lake Depth and Climate Zones.**

The Laurentian Great Lakes, as a whole, have experienced accelerated summertime warming, compared to local terrestrial air and most lakes worldwide. The spatial pattern of warming rates within the Great Lakes, however, has been highly heterogeneous, ranging from +0.02°C/year in southern, shallow Lake Erie to +0.14°C/year in northern, deep Lake Superior, based on the in-situ buoy measurements during 1982-2012. By generating a new dataset of lake surface temperatures with high spatial resolution, it is shown that lake depth and background mean air temperatures are the two primary factors determining the distribution of warming trends, jointly explaining ~70% of the spatial variance. In general, the lake surface has warmed more rapidly over deeper waters and in colder climate zones, as the contribution from milder antecedent winters strongly depends on lake depth and mean timing of spring stratification. The dependence on lake depth and background mean air temperature is not linear, though, as the warming rates have increased markedly with lake depth in the relatively cold climate zones of Lake Superior, but increased little in the warmer climate zones affecting Lake Ontario. Physical causes of this nonlinear dependence are investigated by performing sensitivity experiments with a coupled regional climate model - lake model. *Keywords: Climate change, Atmosphere-lake interaction, Great Lakes basin.*

ZHOU, C.L.[1], ZHOU, H.A.[2], JOHNSON, T.A.[2], CRIMMINS, B.S.[1], HOPKE, P.K.[2], and HOLSEN, T.M.[1], [1]Department of Civil and Environment Engineering, Clarkson University, 8 Clarkson Ave., Potsdam, NY, 13699, USA; [2]Institute for Sustainable Environment, Clarkson University, 8 Clarkson Ave., Potsdam, NY, 13699, USA. **Mercury temporal trends in top predator fish of the Laurentian Great Lakes from 1999 to 2014.**

Trends of mercury (Hg) concentrations in top predator fish (lake trout and walleye) of the Great Lakes from 2004 to 2014 were analyzed using fish length control and age correction. A cluster concept based method was applied for age correction and non-parametric methods, Kendall's tau test and Kendall-Theil robust regression, were applied in trend analysis. Results indicate that the general Hg concentration trend in the Great Lakes top predator fish is decreasing with a rate at 6.3% per year. Lake Huron, Michigan and Superior, which are dominated by atmospheric Hg input, have clear decreasing trends with rates from 4.4% to 9.8% per year; while Lakes Erie and Ontario, which are more influenced by non-atmospheric Hg inputs, have decreasing then increasing trends. The results indicate that, over the last decade, the increasing global Hg emissions have not overwhelmed decreases in regional Hg emissions and the Great Lake ecosystem is responding to decreases Hg emissions in North America. *Keywords: Mercury, Trends, Walleye, Fish Age, Trout, Kendall-Theil method.*

ZHOU, H.A.[1], ZHOU, C.L.[2], and HOLSEN, T.M.[2], [1]Institute for a Sustainable Environment, Clarkson University, 8 Clarkson Ave., Potsdam, NY, 13699, USA; [2]Department of Civil and Environmental Engineering, Clarkson University, 8 Clarkson Ave., Potsdam, NY, 13699, USA. **Atmospheric Mercury Temporal Trends in the Northeastern Great Lakes Region from 2005 to 2014.**

Long term atmospheric mercury measurements from Huntington Forest, NY and Underhill, VT between 2005 and 2014 have been analyzed for concentration trends using Sen's slope estimator and Mann-Kendall's tau test. All three atmospheric mercury species: gaseous element mercury (GEM), gaseous oxidized mercury (GOM) and particle bounded mercury (PBM) showed declining trends with a rates of 0.8%, 8.73% and 0.14% per year, respectively. The trends and change rates varied with season and wind direction. The decreasing trends are positively correlated with decreased coal combustion in regional electrical generating facilities during the same period. A source contribution analysis using condition probability function (CPF) and potential source contribution function (PSCF) indicates the sources of atmospheric mercury have changed somewhat over this period. The results indicate that decreased mercury emissions during the past decade have reduced atmospheric mercury concentrations at these locations and that increasing global emissions

have not overwhelmed these decreases. *Keywords: Mercury, Trends, Atmospheric circulation, PSCF.*

ZIMMER, C.A. and SINGH, A., Credit Valley Conservation, 1255 Old Derry Road, Mississauga, ON, L5N6R4, CANADA. **Applying a Vulnerability Assessment Framework to Identify Stressors and Maintain Healthy Great Lakes.**

Recent events - such as the Calgary and Toronto 2013 floods have highlighted the need to develop a better understanding of the risks and linkages between water infrastructure and our environment including impacts to public health, emergency response services, our natural environment and the community. Local climate change predictions suggest more frequent extreme weather events, including heavy precipitation, flooding, droughts, and heat waves, challenging water managers to adapt programs to meet the needs of an uncertain future. Building on existing tools such as the watershed study process, surface and lake modelling, and Public Infrastructure Engineering Vulnerability Commission (PIEVC) Protocol, Credit Valley Conservation, in partnership with member municipalities have undertaken a climate change risk assessment framework to develop an understanding of infrastructure vulnerabilities and linkages including nearshore and instream water quality, lake-based water supply, stormwater and wastewater discharge to Lake Ontario. Climate related risks to infrastructure are quantified through the evaluation of historic costs; projected future risks, a scan of existing initiatives and future initiatives needed to reduce risks and vulnerabilities. *Keywords: Urban watersheds, Climate change, Risk assessment.*

ZOLFAGHARI, K. and DUGUAY, C.R., University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L 3G1, CANADA. **Evaluation of MERIS Chlorophyll-a Retrieval Algorithms for Optically Complex Lake Erie.**

This study presents the first comprehensive evaluation of four well-established MERIS neural network (NN) algorithms as well as two band-ratio chla related indices against insitu measurements for Lake Erie. The investigated products include C2R, EU, FUB/WeW, and CC processors, as well as those from the band-ratio algorithms of FLH and MCI. Two approaches were taken to compare and evaluate the performance of these algorithms to predict chla concentration. First, all available chla matchups are evaluated at once. In the second approach, a classification of three optical water types is applied, and the algorithms' performance is assessed for each type individually. Type 1 and 2 were turbid with the highest concentrations of TSM and chla, respectively, while type 3 was characterized by the highest SDD measurements. Results show that the FUB/WeW processor outperforms other algorithms when the full matchup data of the lake was used (RMSE = 1.99 $mg.m^{-3}$, I_a

= 0.67). However, the best performing algorithm was different when each water optical type was investigated, individually. The best performing algorithm for type 1 was CC_merged, for type 2 CC_NN, and for type 3 C2R. The findings of this study provide valuable information on the effectiveness of different MERIS-based algorithms to derive the trophic state of Lake Erie. *Keywords: Lake Erie, Algae, Remote sensing.*

AUTHOR INDEX

Page numbers denote the following:

BOLD	Author is an oral presenter
ITALIC	Author is a poster presenter
NORMAL	Co-author

A

D

E

H

I

J

K

L

M

N

O

P

S

T

KEYWORD INDEX

A

B

E

F

G

H

N

O

S

T

Z