International Association
for Great Lakes Research

# 57TH ANNUAL CONFERENCE ON GREAT LAKES RESEARCH

at McMaster University
May 26-30, 2014


## ABSTRACTS

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## 57th Annual Conference on Great Lakes Research

**May 26–30, 2014**
**McMaster University**


International Association for Great Lakes Research
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# ABSTRACTS

*An alphabetical listing of abstracts presented at the 57th Annual Conference on Great Lakes Research, organized by first author. Presenters are underlined.*

## A

ABDEL-FATTAH, S.L., Fisheries and Oceans Canada, 59 Larraine Ave., Dundas, On, L9H 6E5. **Risk-Based Assessment of Climate Change Impacts and Risks on the Biological Systems and Infrastructure in the Great Lakes.**

Current management of Great Lakes' resources does not consider environmental variability expected from climate change. Resource managers recognize the need to evaluate the impact of a shifting climate, the uncertainty about the impacts, and consider adaptation strategies. This study aims to identify trends and projections for several variables (including air and surface temperatures, precipitation, ice freeze and break up, lake levels, wind and evaporation) as well as the impacts of the expected changes. There is a general recognition that not all climate variables will change in a linear fashion and that climate variables that are projected to change could interact in complex ways that are not fully understood. This study attempts to recognize the drivers of change in order to identify linkages and interactions between climatic variables and proposed impacts.Past climate trends indicate that the average air temperature in Canada has increased 1.2˚C in the last 58 years (Environment Canada, 2006). Warming has been more significant in winter and spring and has contributed to changes in evaporation rates, less rates, less annual precipitation with less as snowfall and more as rainfall, and shorter periods of ice-cover; all of which affect freshwater ecosystems through hydrodynamic and thermodynamic processes. *Keywords: Climatic data, Risk assessment, Coastal ecosystems.*

ADKINSON, A., DOLSON, R., HANNIKAINEN, P., LA ROSE, J., LANGLEY, T., LIDDLE, G.E., ROBILLARD, M., and TRUMPICKAS, J.J., Southern Biodiversity and

Monitoring Unit, 26465 York Rd. 18, Sutton West, ON, L0E 1R0. **Long-Term Trends and Recent Changes in the Lake Simcoe Fish Community.**

The Lake Simcoe fish community has considerable economic importance and is an important indicator of lake ecosystem health. Since 1954, the Ontario Ministry of Natural Resources has collected information about this fish community through multiple long-term monitoring programs. Monitoring data has shown significant fish community responses to environmental stressors and subsequent lake-wide rehabilitation efforts. Recent trends in the cold-water fish community have included encouraging evidence of natural reproduction and increasing relative abundances of lake trout, lake whitefish, and cisco. Decreasing relative abundance of introduced rainbow smelt has also been observed. The diverse warm-water fish community has been influenced by recent introductions of non-native species like round goby , black crappie, and bluegill. Bluegill relative abundance has increased considerably in recent years and round goby has spread throughout the lake. Overall, there has been high variability in the relative abundance of warm-water fish species, with significant trends exhibited by some species, such as an apparent decrease in relative abundance of smallmouth bass. These fish community trends are discussed in the context of ecological changes and management activities occurring in the Lake Simcoe watershed. *Keywords: Species diversity, Lake Simcoe, Fish populations.*

AGBOOLA, A. and HAFFNER, G.D., Great Lakes Institute for Environmental Research , University of Windsor, 401 Sunset Ave, Windsor, ON, N9B 3P4. **Primary Productivity in the Western Basin of Lake Erie in 2013.**

The goal of this study was to quantify primary production in the Western Basin of Lake Erie to determine whether if current rates of primary productivity differ significantly from historic values in an era when harmful algal bloom are becoming more prevalent. Water samples were collected at varying depth between 0m - 7m in Lake Erie at Middle Sister Island (MSI) and Colchester Reef (CR), and primary productivity was measured at depth using the Light and Dark Bottle Method (LBD) through the months of May and October 2013. Results revealed that the primary production for MSI ranged from 1.017 to 4.529 mg C m-3 h-1 and the annual primary production for CR ranged from 0.388 to 2.411 mg C m-3 h-1. These results are significantly lower than those reported by Fitzpatrick et al. in 2007. It is suggested that changes in the ratio of Zeu/Zm might be having a strong regulating effect on primary production in the western basin of Lake Erie. *Keywords: Carbon, Productivity, Lake Erie.*

ALFORD, L.K., University of Michigan, Naval Architecture & Marine Engineering, 2600 Draper Rd., Ann Arbor, MI, 48103. **The Next Step: Microplastic Pollution Prevention.**

As we begin to determine where microplastics are found in the Great Lakes and where the sources of microplastic pollution are located, we need to work towards preventative solutions to this particularly challenging issue. This presentation will cover known and hypothesized sources of microplastic pollution. Based on these sources, there are suggested methods to prevent this pollution, ranging from filtration at wastewater treatment plants to environmental policy. Discussion from session participants is encouraged. *Keywords: Microplastics, Pollution prevention, Pollution sources, Remediation.*

ALLAN, J.D. and SMITH, S.D.P., University of Michigan, School of Natural Resources & Environment, Ann Arbor, MI, 48109. **The Heterogeneous Distribution of Great Lakes Ecosystem Services.**

We explored whether individual ecosystem services were spatially concordant and correlated with socio-economic measures including population and the tourism economy. We created fine-scale maps of use metrics for one provisioning service (commercial fishing) and five cultural services (sport fishing, recreational boating, beach visitation, park visitation and birding) throughout the Laurentian Great Lakes. Individual services generally were widely and unevenly distributed, indicating that most but by no means all locations receive some mix of ecosystem services. Boating, birding, beach use and sport fishing showed strong positive associations with one another at the county scale, while park visits were weakly or not correlated with other recreational services. High recreation activity tended to be located adjacent to major urban areas or well-known vacation destinations. Some 57% of variation in gross domestic product and 46% of variation in employment for tourism and recreation among U.S. counties and was explained by county-level sums of the five recreational services, demonstrating the value of the Great Lakes to shore-adjacent communities. *Keywords: Lake management, Economic evaluation, Spatial analysis.*

ALMEIDA, L.Z.[1], SESTERHENN, T.M.[1], RUCINSKI, D.K.[2], and HÖÖK, T.O.[1], [1]Purdue University, West Lafayette, IN, 47906; [2]Limnotech, 501 Avis Drive, Ann Arbor, MI, 48108. **Effects of Altered Nutrient Loading and Changing Climate on Habitat Quality for Lake Erie Fishes.**

Hypolimnetic hypoxia develops during late summer in central Lake Erie, and the magnitude of this phenomenon is expected to increase with global climate change. While

hypoxia is partially a natural occurrence, anthropogenic-induced nutrient loading can exacerbate hypoxic conditions which is often cited as rationale for programs aiming to reduce nutrient loading. However, while increased nutrient loading may exacerbate hypoxic conditions and thereby affect fish habitat quality, nutrient loading may also increase habitat quality for fish by increasing prey production. To analyze the interplay between the benefits and disadvantages of eutrophication in the central basin of Lake Erie, we used output from a 1D water quality model to drive a growth rate potential (GRP) model exploring the effects of light, prey density, temperature and oxygen on habitat quality of four fish species. We evaluated habitat quality through hindcast simulations, as well as plausible future scenarios of climate warming and altered nutrient loading (both increased and decreased loading). Preliminary results suggest that although there is an increase in the density of prey as temperature and nutrient loading increase, these increases appear to be insufficient to overcome the negative effects of increased hypoxia. *Keywords: Habitat quality, Nutrients, Hypoxia, Climate change, Lake Erie, Growth rate potential.*

AMOS, M.A.[1], PALMER, C.J.[1], STAPANIAN, M.A.[2], LEWIS, T.E.[3], BLUME, L.J.[4], and SCHOFIELD, J.A.[1], [1]CSC, 6361 Walker Lane, Suite 300, Alexandria, VA, 22310; [2]U.S. Geological Survey, 6100 Columbus Avenue, Sandusky, OH, 44870; [3]U.S. Army Corps of Engineers, 3909 Halls Ferry Road, Vicksburg, MS, 39180; [4]U.S. EPA GLNPO, 77 West Jackson Boulevard, Chicago, IL, 60604. **Guidance on Quality Assurance for Ecosystem Restoration in the Great Lakes Basin.**

National & international organizations have been tackling serious threats to ecosystems in the Great Lakes basin such as habitat loss, invasions of non-native species, pollution from toxic compounds, shifts in wildlife populations, & alterations to natural water levels & flow regimes. Once the on-the-ground work has been completed, monitoring must be conducted to ensure planned activities are implemented correctly & are effective in achieving desired outcomes. Practitioners rely heavily on the quality of ecological measurements for monitoring (e.g., visual or auditory observations) but little to no guidance exists to ensure the quality of those measurements. The voluminous data resulting from monitoring efforts have been collected for decades but only recently have practitioners realized that chemistry-based QA/QC applications also are valid in the world of eco-restoration. An interagency QA committee is developing a guidance document to provide information regarding the application of QA/QC aspects to eco-restoration projects, to facilitate project efficiency & success. The guidance is intended for practitioners, stakeholders, and the public to encourage the adoption of QA principles & approaches. This presentation describes the key components of this guidance & requests participation & support from the IAGLR community. *Keywords: Ecosystems, Habitats, Great Lakes basin.*

ANTUNES, P.M.C., HOLTZE, K.E., and NOVAK, L.J., AquaTox Testing & Consulting Inc., 11B Nicholas Beaver Rd., Guelph, On, N1H 6H9. **Implications of changing Great Lakes water quality on trace metal and nutrient partitioning and bioavailability.**

All aquatic organisms have an optimal range of water quality conditions which will allow them to survive, grow and reproduce. Conditions that are outside of this ideal range, including nutrient limited and polluted environments, can challenge the ability of an organism to maintain homeostasis. As such, localized areas within the Great Lakes system experiencing changes in water temperature, sediment re-suspension dynamics, nutrient loading (e.g. increasing $NO_3$ and decreasing P), and hypolimnion hypoxia, will ultimately place some organisms at an advantage over others due to their nutrient sequestration and/or detoxification capacities. Which organisms are best able to take advantage of these conditions has much to do with ion competition and complexation reactions and uptake rates at the solution-exposed surface sites (i.e., the fish gill or algal cells) - considering also the rate of nutrient replenishment in the exposure medium. The focus of this presentation will be on equilibrium chemistry in water and surficial sediments, and how specific changes in water (or porewater) chemistry influences trace metal and nutrient partitioning, nutrient uptake by freshwater biota, as well as the the potential toxicological toxicological impacts on survival in various receiving water environments. *Keywords: Computer models, Nutrients, Biogeochemistry, Metals.*

ANWAR, S.M.S.[1], WOLFE, S.E.[1], SWEENEY, S.J.[2], and ASPINALL, J.D.[2], [1]University of Waterloo, Department of Environment and Resource Studies, Waterloo, ON, N2L 3G1; [2]Ontario Ministry of Agriculture and Food, and Ministry of Rural Affairs, Environmental Management Branch, Guelph, ON, N1G 4Y2. **Agriculture in western Lake Erie Basin watersheds: A Binational analysis of geomatics information resources pertinent to the harmful algal bloom problem.**

The western Lake Erie Basin (WLEB) experiences chronic algal fouling due to elevated nutrient levels. Lake Erie's largest recorded harmful algal bloom (HAB) occurred in 2011 (Michalak et al., 2013). HAB's have significant public health, ecological and economic impacts. Agencies responsible for the binational management of the Great Lakes have declared non-point nutrient source (NPNS) reduction to be a priority. Agricultural management of nutrients in WLEB watershed regions has been implicated as a major NPNS. Lake

Erie HAB issue solutions and mitigation progress tracking will require appropriate geomatics information resource development and maintenance. The current status of the binational situation was examined with respect to agricultural landscape geomatics information resources pertinent to the HAB problem. Publicly available and product-in-development sources were assessed. A significant discrepancy was discovered in both their spatial and temporal resolutions. Recent progress to address this situation is highlighted. Focused resources and work are needed to more closely align these foundational geomatics data sets to better facilitate and track the performance of binational, regional and local approaches to the shared responsibility of mitigating the Lake Erie HAB problem. *Keywords: Agricultural management, GIS, Binational, Lake Erie.*

ARAB, A.[1] and WILDHABER, M.L.[2], [1]Dept of Mathemtics & Statistics, Georgetown University, 322 St. Mary's, Washington, DC, 20057; [2]USGS - Columbia Environmental Research Center, 4200 New Haven Road, Columbia, MO, 65201. **Hierarchical Bayesian Modeling Approaches for Habitat Management of Benthic Fishes in the Missouri River.**

Hierarchical Bayesian modeling approaches provide a flexible and effective tool for modeling problems related to habitat management in fisheries. Using this modeling framework, one is able to account for uncertainties in data and model parameters. Intensive management of the Missouri River such as impoundments, flow regulations, and channelization of the river for purposes of navigation, flood control, and power generation has resulted in dramatic physical changes to the river corridor, eliminating many acres of habitat for native fish. There have been several studies conducted by the U.S. Geological Survey (USGS) to evaluate the impact of such alterations and modifications of the river basin on the recruitment, growth, and relative abundance of selected benthic fish species. In this work, the analysis of catch data obtained by multiple gears using a hierarchical Bayesian zero-inflated Poisson model is discussed. Also, we discuss the extension of this approach to the analysis of multi-species catch data obtained by multiple gears using a semiparametric hierarchical Bayesian multivariate zero-inflated Poisson model. *Keywords: Monitoring, Bayesian Hierarchical Modeling, Habitats, Regional analysis.*

ARHONDITSIS, G.B., Ecological Modelling Laboratory, University of Toronto, Toronto, ON, M1C 1A4. **How reliably can we guide management decisions using mathematical modelling?**

The emergence of the holistic management paradigm has pervaded the contemporary mathematical modelling practice, increasing the demand for more complex ecosystem models. These modelling constructs are designed to shed light on different facets of biogeochemical cycles, but their application involves substantial uncertainty contributed by model structure, parameters, and other inputs. In this study, I will first present the key results of three independent meta-analysis aiming to assess methodological practices and performance trends of watershed, aquatic biogeochemical, and plankton functional group models. I will examine the credibility of the current generation of mathematical models to effectively guide environmental management decisions. In this regard, my thesis is that the Bayesian paradigm is uniquely suitable for developing integrated environmental modelling systems, overcoming the conceptual or scale misalignment between processes of interest and supporting information, and exploiting disparate sources of data that differ with regards to the measurement error and resolution. I will also illustrate some critical issues related to the development of two network of models that aim to connect the watershed processes with the dynamics of the receiving waterbodies in the Hamilton Harbour and Bay of Quinte (Ontario, Canada). *Keywords: Ecosystem modeling, Adaptive management, Watersheds, Bayesian analysis, Urban watersheds, Uncertainty.*

ARIFIN, R.R.[1], DEALWIS PITTS, D.A.[2], JAMES, S.C.[3], SHARMA, A.[1], HAMLET, A.F.[1], and FERNANDO, H.J.[1], [1]Department of Civil & Environmental Engineering and Earth Sciences, University of Notre Dame, Notre Dame, IN, 46656; [2]Center for Research Computing, University of Notre Dame, Notre Dame, IN, 46556; [3]Exponent, 320 Goddard, Irvine, CA, 92618. **Lake Ontario Spring Thermal Evolution Simulation.**

Spring evolution of thermal bar and summer stratification pattern in Lake Ontario during Spring to Summer transition period (2011) are being simulated using the hydrodynamic model Environmental Fluid Dynamics Code (EFDC). The hydrodynamic model, EFDC is not capable with ice sub-module within the heat flux computation module. Lake Ontario being in the temperate zones, experiences cold weather and ice formation even during late Spring. Hence, our simulated surface water temperatures exhibit some negative temperature problems in the beginning phase of the modeling. Different measures have been exercised to mitigate the problem: refining initial temperature conditions and bathymetry data, analyzing heat fluxes, sensitivity analysis on solar radiation coefficients. Simulated temperatures (both horizontal and vertical profiles) from April to June, 2011) are analyzed, comparing with observed station/buoy data and satellite imagery. *Keywords: GIS, Hydrodynamic model, Thermal Stratification, Lake Ontario.*

ARIFIN, R.R.[1], DEALWIS PITTS, D.A.[2], JAMES, S.C.[3], SHARMA, A.[1], HAMLET, A.F.[1], and FERNANDO, H.J.[1], [1]Department of Civil & Environmental Engineering and Earth Sciences, University of Notre Dame, Notre Dame, IN, 46656; [2]Center for Research Computing, University of Notre Dame, Notre Dame, IN, 46556; [3]Exponent, 320 Goddard, Irvine, CA, 92618. **Modeling Thermal Stratification Pattern and Thermal Bar Formation in Lake Ontario.**

Thermal bar is an important phenomenon in large, dimictic, temperate lakes like Lake Ontario. Thermal bar formation reduces horizontal thermal mixing, which in turn inhibits the exchange of nutrients, alters habitats of aquatic species, and may intensify eutrophication (algal blooms). Thermal bar formation and thermal stratification pattern in spring to summer season(2011) through Lake Ontario are simulated using the 3D hydrodynamic model - Environmental Fluid Dynamics Code (EFDC). The model uses as inputs the hourly meteorological data from weather stations around the lake, flow rate and water temperature data for the Niagara and St. Lawrence Rivers, and lake bathymetry data. The simulation is performed for the year 2011, March to August, on a curvilinear grid at 2-km resolution. Refining lake bathymetry, providing depth varying initial temperature condition, sensitivity analysis on horizontal and vertical mixing coefficients and checking heat fluxes helped in fine tuning the simulated temperatures. Comparison of simulated results with remotely sensed surface-temperature data and observed vertical profiles demonstrates that the hydrodynamic model successfully replicates the primary features of hydrothermal behaviors of the lake. *Keywords: Hydrodynamic model, Thermal Stratification, Lake Ontario, Thermal Bar, GIS.*

ARTEAGA, R., NANDAKUMAR, H., KURISSERY, S., and KANAVILLIL, N., Lakehead University Orillia campus, 500 University Avenue, Orillia, ON, L3V 0B9. **Studies of phytoplankton dynamics along the NW shore of Lake Simcoe.**

Phytoplankton dynamics in Lake Simcoe and Lake Couchiching were studied with an aim to use them as a biological indicator of water quality. Surface water samples were collected and hydrological parameters were measured from 6 different shallow, inshore sites located along Lake Simcoe and Lake Couchiching. The study was conducted from September to December, 2013. Biweekly samples were collected and analyzed for phytoplankton density, species composition, and biomass. In addition to major hydrological parameters chlorophyll a, total phosphorus and total nitrogen were also measured. Preliminary results indicated that sites exposed to anthropogenic disturbances recorded higher phytoplankton density (mainly *Aulacoseira granulata*, *Diatoma* spp., and *Navicula* spp.) and species diversity, as well as a greater amount of total suspended load, and chlorophyll a. Hydrological parameters

also suggested that these sites were prone to more anthropogenic activities. Statistical analyses are being carried out on the data with an aim to understand the usefulness of studying phytoplankton dynamics as an indicator of water quality. *Keywords: Bioindicators, Phytoplankton, Distribution patterns.*

ARTS, M.T.[1], KAINZ, M.J.[2], GUSCHINA, I.A.[3], YAN, N.D.[4], KOUSSOROPLIS, A.M.[5], SAWYER, J.M.[6], FISK, A.T.[7], ARHONDITSIS, G.B.[8], DIAMOND, M.[6], WACKER, M.[5], FUSCHINO, J.R.[9], and HARWOOD, J.L.[3], [1]Department of Chemistry and Biology, Ryerson University, Toronto, ON, M5B 2K3; [2]WasserCluster-Biologische Station Lunz, Dr. Carl Kupelwieser Promenade 5, Lunz am See, A-3293, Austria; [3]School of Biosciences, Cardiff University, Cardiff, CF10 3AX, United Kingdom; [4]Department of Biology, York University, Toronto, ON, M3J 1P3; [5]Department of Theoretical Aquatic Ecology - Institute of Biochemistry and Biology, University of Potsdam, Am Neuen Palais 10, Potsdam, D 14469, Germany; [6]Department of Geography, University of Toronto, 100 St. George St., Toronto, ON, M5S 2E5; [7]Great Lakes Institute for Environmental Research and Department of Earth Sciences, University of Windsor, 401 Sunset Ave., Windsor, ON, N9B 3P4; [8]Department of Physical and Environmental Sciences, University of Toronto, 1265 Military Trail, Scarborough, ON, M1C 1A3; [9]Department of Biology, York University, Toronto, ON, M3J 1P3.
**Does Climate Change Have the Potential to Affect the Production and Distribution of Essential Long-Chain Polyunsaturated Fatty Acids (LC-PUFA) in Aquatic and Terrestrial Food Webs?**

Essential LC-PUFA are required to maintain the health and vitality of both aquatic and terrestrial animals. They contribute, in demonstrable ways, to cardiovascular and neural/cognitive health of vertebrates thus affecting both recruitment and survival and also "quality of life". They are an integral part of our global food chain. But where do they ultimately come from and what are some of the threats to their sustained production on a global basis? Here we review the current evidence that climate change may be acting, in various interrelated ways, to reduce the production of essential LC-PUFA at the base of aquatic food webs. We will also briefly discuss the ramifications of these phenomena for the ultimate transfer of these essential compounds to the terrestrial organisms that also depend on them. *Keywords: Essential fatty acids, Ecosystem health, Climate change.*

ASPINALL, J.D., SWEENEY, S.J., VANTHOF, V.R., NAIR, M., and NUSSLI, E.R., Ontario Ministry of Agriculture and Food and Ministry of Rural Affairs, Environmental Management Branch, Guelph, ON, N1G 4Y2. **High-resolution characterization of the sur-**

**viving organic soil resource after the Summer 2014 floods of the vegetable fields at Horling's Marsh, Ontario.**

The organic soils of the Holland Marsh and other agricultural polder areas in the southern Lake Simcoe watershed area are highly productive for vegetable cropping. One of these areas, the Horling's Marsh, is located on the eastern side of the Town of Bradford. Approximately 190 acres of carrots were planted on its four fields for the 2014 crop. This marsh's protective perimeter dyke was breached on May 25, 2014. Its flood waters destroyed the young crop. A second breach on June 16, 2014, occurred after a second carrot crop was planted. Flood waters from both events scoured and displaced the organic soil at this site. A very high-resolution assessment of the surviving organic soil resource was conducted. Over 800 individual soil site investigation points were examined. Mobile mapping technology was used to geo-locate and record all surviving soil thickness field observations. A high-resolution laser scanner was used to capture a digital elevation model (DEM) of the post-flood soil surface. A pre-flood DEM surface was generated from an elevation data cloud developed from April 2013 digital orthophotography. Direct overlay and difference analysis of these surfaces delineated all areas of soil mobility - accumulations and losses - due to the flooding. Most field surface areas survived these flooding events essentially unchanged. *Keywords: Organic Soils, Vegetable Fields, Lake Simcoe, Flooding.*

AUDET, C.A.[1] and PITCHER, T.E.[2], [1]Department of Biological Sciences, University of Windsor, 401 Sunset Ave., Windsor, ON, N9B3P4; [2]Great Lakes Institute for Environmental Research, University of Windsor, 401 Sunset Ave., Department of Biological Sciences, University of Windsor, 401 Sunset Ave., Windsor, ON, N9B3P4. **The Effects of Intraspecific Hybridization on the Reintroduction of Atlantic salmon (*Salmo salar*) to Lake Ontario.**

Intraspecific hybridization includes the crossing of individuals from two distinct populations that are distinguishable by at least one characteristic. The fitness of hybrid offspring can be superior (hybrid vigour) or inferior (hybrid breakdown) relative to the fitness of parental populations. Previous studies have demonstrated hybrid vigour and hybrid breakdown when breeding different salmonid populations, it may therefore be relative to ongoing efforts to reintroduce Atlantic salmon (*Salmo salar*) to Lake Ontario using three distinct populations (LaHave (L), Sebago (S) and St. Jean). Atlantic salmon were once native to Lake Ontario but they were extirpated in the early 20th century as a result of anthropogenic causes. Despite ongoing restoration efforts, there is currently no self-sustaining population of *S. salar* in Lake Ontario. This study aims to evaluate whether crossing different populations (using Sebago and LaHave as focal populations) will result in the expression of hybrid vigour or hybrid breakdown in juveniles. This will be accomplished by using fifteen half-sib blocks consisting of a pure Sebago and a pure LaHave cross, and their reciprocal hybrids (L♀ x S♂, S♀ x L♂) in order to compare multiple traits associated with individual fitness between the four groups within each family unit. *Keywords: Salmon, Reintroduction, Lake Ontario.*

AUER, M.T., Great Lakes Research Center, Michigan Technological University, Houghton, MI, 49931. **End Game On The Commons.**

The Great Lakes have entered the 21st Century experiencing a suite of problems that are as 1970s as a pair of bell bottom pants. Most people expected that phosphorus, cyanobacteria and Cladophora would have gone the way of fires on the Cuyahoga long before this. The problems manifested in a 21st Century Great Lakes environment suddenly appear intractable. It is as in the end game in chess, where few pieces remain on the board and the player must seek to secure a win when there is no obvious way to win. This paper will posit that success in an end game environment requires a metanoia, a change in the way that we perceive the nature and value of the Lakes and the immediacy and significance of our personal and corporate commitment to their health. That commitment will be formed on a personal level if we are able to nurture reverence for the Lakes and at a corporate level when we learn to view the Lakes as a commons, belonging to none and to all. The portal to this metanoia may reside in recognition of the value of alternative philosophies, particularly those of indigenous peoples. *Keywords: Environmental policy, Public participation, First Nations.*

AUER, M.T., Great Lakes Research Center, Michigan Technological University, Houghton, MI, 49931. **End Game Great Lakes.**

In the last three decades of the 20th Century, Great Lakes environmental managers successfully responded to ecosystem perturbations that included invasive species (sea lamprey), nutrient discharges (phosphorus) and atmospheric deposition of organic chemicals (toxaphene). Now, in the 21st Century, the Lakes are again challenged by invasive species (dreissenids), nutrient discharges (phosphorus) and organic chemicals (PPCPs). In the eyes of some, these perturbations seem less tractable either in an intrinsic sense (dreissenids) or due to the level of development and economic pressure in the watershed. The end game in chess occurs when few pieces remain on the board and there are limited options available for securing a successful outcome. This paper will examine the phosphorus-dreissenid-Cladophora dynamic along the waterfront of the Golden Horseshoe in western Lake Ontario and in that portion of Lake Erie impacted by phosphorus loads from the Maumee River. The extent to which dreissenids have placed the Great Lakes in an end game position will be examined and the steps necessary to address water quality degradation in the nearshore identified. The conclusion is reached that a metanoia, a change in the way we think about Great Lakes management, will be required in order to find a successful path through the end game. *Keywords: David Dolan, Cladophora, Phosphorus.*

AUER, M.T.[1], DEPINTO, J.V.[2], and CHAPRA, S.C.[3], [1]Great Lakes Research Center,, Michigan Technological University, Houghton, MI, 49931; [2]LimnoTech, 501 Avis Drive, Ann Arbor, MI, 48108; [3]Civil and Environmental Engineering, Tufts University, Medford, MA, 02155. **Dave Dolan Contributions to Great Lakes Research and Management.** This talk will present a summary of Dave Dolan's many contributions to the Great Lakes, in both research and management. *Keywords: Loading, Nutrients, Model studies.*

AUER, N.A., Michigan Technological University, Biological Sciences, 740 DOW BLDG.,1400 Townsend Dr., Houghton, MI, 49931. **Can We Build Reverance for Great Lakes By Example?**

This presentation will build on those given by others in Session 25 discussing the potential to regard the Great Lakes as a commons, and how to build a greater respect for the Lakes and all they sustain. Our youth have begun to lose connection to experiences within nature, which appears to result in seeing natural systems as simply providing services; water, food, transportation. Deeper connections to nature and our potential to learn from other peoples and examples are viewed as critical to developing policy. *Keywords: Great Lakes basin, Ecosystems, Vision.*

AUKES, P.[1], HUTCHINS, R.[2], ELGOOD, R.J.[1], and SCHIFF, S.L.[1], [1]University of Waterloo, 200 University Avenue, Waterloo, ON, N2L 3G1; [2]Université du Québec à Montréal, 2080 St-Urbain, Montréal, QC, H2X 3X8. **Characterization of Dissolved Organic Matter Composition and Quality along the Grand River.**

Dissolved organic matter (DOM) influences a number of important processes within the environment, ranging from regulating thermal regimes to acting as an important nutrient for microbes. During water treatment processes, DOM can negatively impact water quality through the formation of carcinogenic disinfection by-products. However, the extent DOM reacts with the surrounding environment is dependent upon its quality. DOM consists of thousands of molecules with differing structural and chemical characteristics, making DOM quality analysis expensive, time consuming, and complicated. Use of Liquid Chromatography - Organic Carbon Detection (LC-OCD; size exclusion column technique) is a simple method that separates DOM into groups with similar structural and electrostatic properties, allowing for rapid and detailed characterization and insight into what groups determine its overall quality. We used LC-OCD and PARAFAC analysis to characterize DOM along the length of the Grand River. Current data suggests that wastewater effluent may permanently alter DOM character downstream of large urban areas. *Keywords: LC-OCD, Dissolved organic matter, Water quality.*

AUSTIN, J.A.[1] and BRETHAUER, J.[2], [1]Large Lakes Observatory and Department of Physics, University of Minnesota Duluth, Duluth, MN, 55812; [2]Department of Physics, University of Minnesota Duluth, Duluth, MN, 55812. **Observations of radiatively driven convection in a deep, dimictic lake.**

When springtime solar radiation is incident on a lake whose temperature is below the temperature of maximum density, the lake can undergo convective overturn in the absence of wind mixing, redistributing heat over the entire water column in just hours. This process has no oceanographic analog, where convection typically occurs under cooling conditions, in which vertical mixing is driven simultaneously by heat loss and wind mixing. Observations of this process have been made in Lake Superior on multiple moorings over the course of several years, as well as from an autonomous glider. These observations show a dependence of the size of the instability generated during convection to depend on wind speed and cloud cover, with larger instabilities forming on sunny, still days. Prior to the onset of summer stratification, convection can occur across the temperature of maximum density curve. Glider data suggest that chlorophyll can be vertically transported during these events. *Keywords: Atmosphere-lake interaction, Thermal structure, Lake Superior, Convection.*

# B

BAI, X.[1] and WANG, J.[2], [1]CILER, University of Michigan, 4840 South State Rd., Ann Arbor, MI, 48108; [2]NOAA/GLERL, 4840 South State Rd., Ann Arbor, MI, 48108. **A Record-Breaking Low Ice Cover over the Great Lakes during Winter 2011/2012: Combined Effects of a Strong Positive NAO and La Niña.**

A record-breaking low ice cover occurred in the North American Great Lakes during winter 2011/2012, in conjunction with a strong positive North Atlantic Oscillation (NAO) and a La Niña event. Large-scale atmosphere circulation in the North America region reflected a combined signal of La Niña and +NAO. Analysis indicates that neither La Niña nor +NAO alone can be responsible for the extreme warmth; the typical mid-latitude response to La Niña events is a negative PNA pattern, which does not have a significant impact on Great Lakes winter climate; the positive phase of NAO is usually associated with moderate warming in the Great Lakes region. When the two occurred simultaneously, the combined effects of La Niña and +NAO resulted in a negative East Pacific pattern with a negative center over Alaska/Western Canada, a positive center in the eastern North Pacific, and an enhanced positive center over the eastern and southern United States. The overall pattern prohibited the movement of the Arctic air mass into mid-latitudes and enhanced southerly flow and warm advection from the Gulf of Mexico over Great Lakes region, leading to the extreme warmth during the 2011/12 winter. It is another climatic pattern that can induce extreme warming in the Great Lakes region in addition to strong El Niño events. *Keywords: Climates, Ice.*

BAINES, P., Great Lakes Commons Map, PH5, 200 Dufferin Street, Toronto, ON, M6K 1Y9. **An Engagement Compass for a Great Lakes Commons.**

Measuring the health and changes to the Great Lakes requires the most accurate and relevant tools. We measure only what we decide to look for and what we capture by our techniques. This presentation will explore the work done so far to recognize and organize our Great Lakes into a shared commons. Commons are the elements, inventions. and interventions that are given to us as gifts from the past and summon our shared duties to protect them into the future. Whether they are limitless (like new knowledge and even recipes) or finite (like the radio spectrum and public beaches) a commons is a social agreement on how to share its abundance and avoid its abuse. There are many threats facing the Great Lakes. Our tools have mostly been measuring the water's quality and quantity. We now have the most advanced knowledge of these threats but are we missing some other significant forms of measurement? The lakes are dying. Braiding an emerging water-commons ethic with an Indigenous Rights-based strategy, this presentation showcases a commons compass tool. It is a measure of both public engagement and shared commitment. A Great Lakes Commons compass tool reorients our methods and messages on how we honour: First Nations treaties; a watershed's integrity. human equity across space and time, and access to the decision-making processes. *Keywords: Treaties, Great Lakes basin, Governance.*

BALDRIDGE, A.K.[1], FAHNENSTIEL, G.L.[2], LIEBIG, J.R.[3], NALEPA, T.F.[4], POTHOVEN, S.A.[3], RUTHERFORD, E.S.[3], and VANDERPLOEG, H.A.[3], [1]CILER, University of Michigan- SNRE, Ann Arbor, MI, 48109; [2]Michigan Technological University, Great Lakes Research Center, Houghton, MI, 49931; [3]NOAA GLERL, 4840 S. State Rd, Ann Arbor, MI, 48108; [4]Water Center, University of Michigan, Ann Arbor, MI, 48104. **Exploring the relative impacts of climate change and dreissenid mussels on the Lake Michigan zooplankton community.**

Climate change and invasive species have caused substantial ecological changes to the Lake Michigan food web, but their relative impacts have not been compared. To examine the relative impacts of dreissenid mussels and climate change, we analyzed the biomass of zooplankton taxa grouped by feeding strategy (diaptomids, cyclopoids, filter-feeding cladocerans, and predatory cladocerans) between warm and cool years, and before and after mussel establishment. The data used were collected between 1994 and 2012 from an offshore site in Lake Michigan. To account for seasonal variation within each year, we analyzed biomass within pre-, early, and late stratification periods. Results suggest that dreissenid and climate effects on zooplankton are group and period specific. For diaptomids during pre-stratification, only the interaction between dreissenids and temperature was significant. During early stratification, neither temperature nor dreissenids significantly affected zooplankton biomass. During late stratification, biomass of cyclopoids was higher in warmer years and biomass of diaptomids was greater following establishment of dreissenids. Future work will explore interactions between dreissenids, climate change, and higher trophic levels. *Keywords: Biological invasions, Zooplankton, Climate change, Dreissenid musselt, Lake Michigan.*

BARBIERO, R.P.[1], LESHT, B.M.[2], and WARREN, G.J.[3], [1]CSC, 1359 W. Elmdale Ave. Suite 2, Chicago, IL, 60660; [2]CSC and University of Illinois at Chicago, 845 W Taylor St., Chicago, IL, 60607; [3]USEPA Great Lakes National Program Office, 77 W. Jackson Boulevard, Chica-

go, IL, 60604. **Changes in the crustacean zooplankton community in Lake Ontario, 1997-2011.**

Crustacean zooplankton communities in Lake Ontario have undergone substantial changes between 1997 and 2011, shifting from a community dominated by cyclopoid copepods and smaller cladocerans to one with a greater percentage of calanoid copepods. Non-predatory cladoceran dominance shifted from bosminids and *D. retrocurva* to the larger *D. mendotae*, while amongst predatory cladocerans *Cercopagis* populations declined and *Bythotrephes* reached substantial numbers in the offshore for the first time. These changes, which became apparent in 2004, represent a shift from a community whch has been stable in the lake for at least 40 years. Unlike the somewhat similar changes seen recently in Lake Huron and Michigan zooplankton communities, the shifts in Lake Ontario have not been accompanied by a trend towards increased oligotrophy. A more likely explanation for the shifts in crustacean zooplankton composition is decreased vertebrate predation, likely due to alewife declines, and changes in the predatory invertebrate community. *Keywords: Crustaceans, Bythotrephes cederstroemii, Lake Ontario.*

BASU, N.B. and VAN METER, K.J., University of Waterloo, 200 University Ave. W., Waterloo, ON, N2L 3G1. **Landscape Nutrient Legacies and Time Lags: A Conceptual Framework.**

Agricultural intensification and urbanization have been responsible for water quality problems both locally, in the Great Lakes Region, and globally. Best management practices (BMPs) employed to combat such problems often fall short of expectations, leading to disillusionment regarding their efficacy. Both biogeochemical and hydrologic nutrient legacies can contribute to this apparent lack of response, causing time lags between BMP implementation and water quality outcomes. Integrated frameworks are necessary to predict the water-quality impacts of climate and land-use shifts across scales, and to link intensive agricultural management to the cascade of ecological impacts in downstream water bodies. We address the following: (1) What are the dominant controls on spatial patterns of catchment hydrologic and biogeochemical responses in human-dominated landscapes? (2) What are the time lags between changes in management practices (e.g. fertilizer application rates, cropping patterns) and changes in water quality in receiving water bodies? We propose a framework within which to explore spatio-temporal relationships between nutrient inputs and water quality in anthropogenic landscapes, using a multi-scale data -synthesis, monitoring and modeling approach and focusing on a quantification of time lags in catchment response. *Keywords: Nutrients, Model studies, Watersheds.*

BAXTER-GILBERT, J.[1], RILEY, J.[2], BOYLE, S.P.[1], LESBARRÈRES, D.[1], and LITZGUS, J.D.[1], [1]935 Ramsey Lake Rd, Sudbury; [2]Balaclava Rd, Sydney, Australia. **Understanding the Road Ahead: A Comprehensive Evaluation of Mitigation Measures Used to Reduce Reptile Road Mortality and Maintain Population Connectivity.**

Roads pose serious threats to reptile populations. The installation of mitigation measures is becoming increasingly common, yet studies that rigorously evaluate the effectiveness of these conservation tools remain rare. The recent Highway 69 expansion along the Georgian Bay coastline has included a series of mitigation measures designed to offset detrimental effects to threatened reptile species. We used a Before-After-Control-Impact study to compare reptile abundance on the highway before and after mitigation using test and control sites. Radio telemetry and wildlife cameras were used to monitor reptile movements and ecopassage use. Additionally, a willingness to utilize experiment was conducted to quantify turtle behavioural responses to ecopassages. We found no difference in abundance of turtles on the road between the un-mitigated and mitigated periods, and an increase in mortality rates for both turtles and snakes post-mitigation. The ecopassages were used by reptiles, the numbers of crossings through ecopassages were low, and turtle's willingness to use ecopassages was lower than that reported in previous arena studies. Our rigorous evaluation of roadway mitigation demonstrates that when exclusion structures fail, the effectiveness of population connectivity structures is compromised. Our study stresses the importance *Keywords: Mitigation, Conservation, Road ecology, Reptiles.*

BECHLE, A.J. and WU, C.H., University of Wisconsin Madison, 1415 Engineering Drive, Madison, WI, 53706. **The Great Lakes Meteorological Tsunami Climate.**

Meteotsunamis (or meteorological tsunamis) are propagating water waves generated by a moving atmospheric disturbance. Meteotsunamis exhibit many similarities to seismic tsunamis, as both have wave periods from 2 minutes to 2 hours and can undergo resonant amplification that transforms relatively small waves in open water into destructive forces at the coast. In the Great Lakes, there have been several destructive meteotsunamis in the past century which have resulted in property damage, injuries, and drownings. In this talk, the frequency of meteotsunami occurrences across the Great Lakes will be examined from water level records over the past two decades. Statistical models are fit to these data to predict the probability of meteotsunamis throughout the Great Lakes. In addition, meteorological records, along with radar and satellite imagery, will be utilized to characterize the meteorological conditions that accompany these meteotsunami events. The results of this study will help quantify the risk associated with these destructive waves and understand the causative meteorology. *Keywords: Waves, Risk assessment, Water level fluctuations.*

BECKER, R.H., COUSINO, L.K., and ZMIJEWSKI, K.A., Department of Environmental Sciences, University of Toledo, 2801 Bancroft Ave, Mail Stop 604; DES, Toledo, OH, 43606. **Modeling The Effects Of Tillage Practices On Sediment And Nutrient Loading In The Maumee River.**

A SWAT hydrologic model of the Maumee River basin in NW Ohio was constructed to determine the relative effects of different drivers on sediment and nutrient flow in the river. The Maumee River watershed is the largest in the Great Lakes region, draining an area over 16,000km$^2$. Though it only contributes a small percentage of the water into the Western Basin of Lake Erie, it contributes by far the largest volume of sediment. Approximately 80% of the watershed is agricultural land usage. Conservation tillage was introduced in the 1980's as a means of reducing sediment/nutrient loads. Recent years have seen reduced sediment yields within the Maumee River, however total phosphorous concentrations have risen over the same time period. A calibrated ArcSWAT model using 1992 land use practices, hydrograph sediment and nutrient data from the Waterville, OH USGS gauging station was used to test the used to test the hypothesis that the implementation of conservation tillage could explain both the overall reduction in sediment and increase phosphate peaks in the later summer months. It was found that historical weather variability was sufficient to explain the increase in late summer phosphate peaks; weather and conservation tillage explained the overall reduction in sediment load. *Keywords: Hydrologic cycle, Sediment load, Model studies.*

BEDFORD, K.A., BOWEN, K.L., CURRIE, W.J.S., and KOOPS, M.A., Fisheries and Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **Zooplankton Production and Biomass in Hamilton Harbour from 2002-2013.**

Hamilton Harbour is an Area of Concern that has long been a highly stressed ecosystem, largely due to industrial development, urbanization and invasive species. Despite high nutrient levels, hypolimnetic hypoxia and contaminated sediment, it is a uniquely productive ecosystem compared to Lake Ontario. DFO has conducted regular sampling of zooplankton, rotifers, nutrients, light attenuation, primary production and microbial food web at several harbour sites from 2002-2013. We will examine seasonal and yearly changes in zooplankton and rotifer biomass, production, species composition and size, and how they interact with other limnological parameters. Of particular interest is how low oxygen conditions affect zooplankton depth distribution. Initial results indicate at least some zooplankton were present at low oxygen levels. Mean May to October zooplankton biomass is often ten times higher than at adjacent lake sites. The harbor is often dominated by small cladocerans such as *Bosmina*, suggestive of high planktivory. Hamilton Harbour is an important fish nursery area, and juveniles of many species feed on zooplankton. Dreissenid veligers are far less common here compared to nearshore Lake Ontario. Cyclopoid copepods remain abundant despite an apparent collapse in Lake Ontario over the last decade. *Keywords: Zooplankton, Hamilton Harbour, Productivity.*

BELETSKY, D.[1], BELETSKY, R.[1], SIERACKI, J.L.[2], BOSSENBROEK, J.M.[2], CHADDERTON, W.L.[3], and RUTHERFORD, E.S.[4], [1]CILER, University of Michigan, Ann Arbor, MI; [2]University of Toledo, Toledo, OH; [3]The Nature Conservancy, South Bend, IN; [4]NOAA GLERL, Ann Arbor, MI. **Modeling spread of invasive species in Lake Michigan.**

Knowledge of invasive species dispersal is key for early detection and rapid response. We studied potential dispersal of invasive ruffe and golden mussel (Limnoperna) in Lake Michigan using a 3D particle transport model. Advection fields were derived from the 10-year hydrodynamic model run. We predicted larval transport from ballast release points located along major shipping lanes, ports (and vicinity), and major tributaries. Ruffe larvae were released at surface daily from mid-April to mid-May and tracked for 7 days while Limnoperna larvae were released from mid-May to September and tracked for 70 days. We targeted larvae settlement in nearshore waters: ruffe settles in waters < 10 m deep while Limnoperna settles in waters < 50 m deep. In mid-lake ballast releases, Limnoperna larvae drifted eastward (reflecting prevailing surface currents) and colonized nearshore areas on the east coast. In contrast, due to differences in seasonal and drift duration, dispersal of ruffe larvae was minimal, reducing chances of survival. Larvae released from ports and river mouths showed very small dispersal for both species, drifting only a few kilometers before settling (although Limnoperna spread was stronger). Dispersal was much stronger from ballast release locations near ports (5 and 10 km offshore), especially for Limnoperna.

BENCE, J.R.[1], DOBIESZ, N.E.[1], BRENDEN, T.O.[1], and HE, J.X.[2], [1]QFC - Department of Fisheries and Wildlife, 153 Giltner Hall, East Lansing, MI, 48824; [2]Michigan Department of Natural Resources, 160 East Fletcher Street, Alpena, MI, 49707. **Using a Stochastic Model**

**to Evaluate the Past and Future Role of Predators in Changes to Lake Huron's Main Basin Fish Community.**

A fish community model consisting of the historically dominant piscivores in Lake Huron's main basin and alewife and rainbow smelt was developed starting in the mid-2000s. This model consisted of age-structured populations with trophic linkages via the predator's functional response. Since that work was initiated new data and stock assessments have become available, including a substantial revisions to lake trout, walleye, and Chinook salmon stock assessments, new diet data, the emergence of round gobies as an important prey species for some predators, and evidence that lake whitefish are an important predator on round gobies. In addition there is substantial evidence suggesting bottom up effects on the ecosystem. We will adapt the stochastic simulation model to account for this information and use it to evaluate the potential role of predators in the substantial decline in alewife abundance in 2003-2004 and their sustained lower abundances, and in the dynamics of round gobies. We will consider how potential changes in prey fish stock-recruitment functions due to bottom-up effects could have played a role in the changes in the fish community. *Keywords: Fisheries, Fish community model, Lake Huron, Fish populations.*

BIASTOCH, R.G., 5 Shoreham Drive, Toronto, ON, M3N 1S4. **Spatial and temporal trends in Toronto and Region Conservation Authority benthic macroinvertebrate communities from 2001-2012.**

Benthic macroinvertebrates (BMI) were sampled at 143 stream sites in 10 Toronto and Region Conservation Authority (TRCA) watersheds from 2001-2012. At the regional scale, a redundancy analysis demonstrated that catchment-scale urbanization variables and in-stream habitats were the two strongest ecological gradients influencing BMI community composition. Road density (km/km2) demonstrated significant relationships with % Oligochaeta, genus richness, Hilsenhoff Biotic Index (HBI), and Simpson's diversity. BMI genus richness decreased sharply at road densities above 9 km/km2. At the watershed scale, Etobicoke Creek demonstrated significant temporal trends in % Oligochaeta and HBI, and Rouge River in % Oligochaeta. Analysis of variance tests detected significant differences in the four indices between watersheds which indicated that Highland Creek, Don River, Frenchman's Bay, Etobicoke Creek, Mimico Creek, and Petticoat Creek watersheds exhibited the poorest ecological health. Duffins Creek, Humber River, Rouge River, and Carruthers Creek were the healthiest watersheds. If low impact design technologies could limit road densities for future developments in urban watersheds to 9 km/km2 or less, BMI communities would be more diverse and perhaps other consequences of urbanization and impervious surfaces would be mitigated. *Keywords: Urbanization, Benthos, Biomonitoring.*

BIBERHOFER, C.R. and CHOW-FRASER, P., McMaster University, 1280 Main Street West, Hamilton, On, L8S 4L8. **Thermal habitat utilization by northern pike in Tadenac Bay, Georgian Bay.**

It is well established in literature that northern pike require littoral habitats, most notably wetlands throughout all stages of their life cycle. The literature indicates that water temperatures ranging from 4-27°C are suitable although the optimal growth for adults is 19-21°C. For a given site the amount of thermal habitat that is available depends on the bathymetry of the site as well as the water level. In Georgian bay, there has been a 1m drop in water levels over the past 15 years, which prompted us to conduct a study in Tadenac Bay, a pristine embayment in eastern Georgian Bay. Our goals were to determine 1) how the amount of thermal habitat changes seasonally and annually and 2) how tagged fish use these different habitats. For the active seasons in 2011 and 2012, we calculated weekly volumes of each 2°C thermal stratum from 13-27°C. Usage of these thermal layers differed between years and according to the size of the fish. Pike used thermal habitats that approached the published lethal limit of 28°C. Our results suggest that thermal habitat suitability based on existing literature (mostly laboratory studies) may not apply to Georgian Bay. *Keywords: Georgian Bay, Northern pike, Wetlands, Thermal Habitat, GIS.*

BIBERHOFER, J. and SMITH, C.J., Environment Canada, WSTD, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **Underwater Video Documentation of Selected Offshore Reefs and Shoals in Lake Huron.**

The recent condition of substrate on offshore reefs and shoals in Lake Huron has been documented at multiple sites with an underwater video system. The instrumentation, which includes cameras and lighting, a CTD and current meter, was deployed on semi-autonomous mooring that afforded stable platform for video and data recording. At each site, the type and condition of substrate, was documented as well as the distribution and relative density of dreissenid mussels and benthic algae. Several sites specifically targeted the areas previously described by Edsall et al (1992) during their 1990, pre-dreissenid, survey of offshore reefs. Prior to the surveys, a 3D bathymetry model was developed for Lake Huron and Georgian Bay as a decision support tool for site selection that has also proven useful for other investigations. *Keywords: Dreissena, Habitats, Lake Huron.*

BIDDANDA, B.A., WEINKE, A.D., and KENDALL, S.T., Grand Valley State University, 740 W. Shoreline Dr., Muskegon, MI, 49441. **Systematically Variable Carbon Metabolism in a Great Lakes Coastal Zone.**

During the summers of 2002 to 2013, we measured rates of carbon metabolism in six sites across a land-to-lake gradient from upstream end of drowned river-mouth Muskegon Lake to 19 km offshore in Lake Michigan. Despite considerable inter-year variability, the generally high rates of gross production (GP), respiration (R), and net production (NP) in Muskegon Lake decreased steeply in offshore Lake Michigan. Along this land-to-lake gradient, GP decreased by 96 ± 1%, whereas R only decreased by 75 ± 10%, variably influencing the carbon balance along this coastal zone. All Muskegon Lake sites were consistently net autotrophic (Mean GP:R = 2.7), while the furthest offshore Lake Michigan site was mostly net heterotrophic (Mean GP:R = 0.4). A recent drop in GP at the shelf edge may reflect increased bentho-pelagic coupling due to invasive mussels. GP, R, and NP were positively correlated with water temperature. Muskegon Lake and Lake Michigan were significantly different in chlorophyll a, GP, R, and NP. Our decade-long study suggests that these estuary/near-shore waters are net carbon sinks that transition into carbon sources in offshore waters. Similarly reactive and dynamic coastal zones everywhere may be contributing substantially to regional and global carbon cycles. *Keywords: Carbon cycle, Coastal ecosystems, Lake Michigan.*

BINDING, C.E., GREENBERG, T.A., and WATSON, S.B., Environment Canada, 867 Lakeshore Road, Burlington, ON, L9H 4G4. **Long Term Water Clarity Changes in the Great Lakes from Multi-sensor Satellite Observations.**

Water clarity in the Great Lakes has undergone considerable change over the last several decades as a consequence of invasive species, eutrophication, and implemented nutrient management practices. This study utilises satellite remote sensing reflectance observations from the CZCS, SeaWiFS, and MODIS sensors in tandem with long term records of Secchi disk depth to provide a retrospective analysis of spatial and temporal variations in water clarity over the Great Lakes. Over 14,000 historical Secchi disk measurements were used to verify sensor continuity across the three missions of aquatic colour observations. Imagery suggests remarkable changes in water clarity over the last three decades in response to the combined effects of dramatic reductions in lake bioproductivity, changes to algal bloom dynamics, removal of particulate material through mussel filter-feeding, decrease in the frequency and intensity of whiting events, and potential changes to sediment resuspension dynamics. Results show clear lake by lake modifications to seasonal fluctuations in wa-

ter clarity in addition to a temporal divergence in lake water clarity between nearshore and offshore environments. *Keywords: Great Lakes basin, Remote sensing, Water quality.*

BLANKEN, P.D.[1], SPENCE, C.[2], LENTERS, J.D.[3], PETCHPRAYOON, P.[1], and GRONEWOLD, A.D.[4], [1]University of Colorado, Department of Geography, Boulder, CO, 80309-0260; [2]Environment Canada, Saskatoon, SK, S7N 5C8; [3]LimnoTech, Ann Arbor, MI, 48108; [4]NOAA - GLERL, Ann Arbor, MI, 48108-9719. **Impacts of Ice Cover on Great Lakes Evaporation: An Analysis of Simultaneous Ice-covered and Ice-free Conditions on Lakes Michigan and Huron During the 2013-14 Winter.**

Our understanding of the influence of ice cover on the rate of evaporation from the Great Lakes remains unclear. Ice cover is highly variable in both space and time, and poorly understood feedbacks between the lakes and atmosphere hinder our ability to predict fluctuations in water levels due to wintertime ice conditions. For the first time, simultaneous in-situ measurements of winter evaporation in 2013-14 were made from offshore locations during ice-covered and ice-free conditions on Lake Michigan and Lake Huron, respectively. Eddy covariance measurements show the "inhibiting" influence of ice formation and growth on northern Lake Michigan evaporation rates, while concurrent measurements on northern Lake Huron show how the cold, dry air associated with the "Polar Vortex" resulted in high evaporation and heat losses over areas that still had open water. This direct comparison illustrates how ice impacts the surface energy balance, thereby giving us a better understanding of how water levels are affected by current and predicted ice conditions on the Great Lakes. *Keywords: Air-water interfaces, Water level fluctuations, Hydrologic cycle.*

BOEHLER, J.A.[1], JOHNSON, L.T.[1], BOEHLER, C.T.[2], KRIEGER, K.A.[1], and BAKER, D.B.[1], [1]National Center for Water Quality Research, Heidelberg University, Tiffin, OH, 44883; [2]The Ohio State University, Mansfield, OH, 44906. **Complex Macroinvertebrate Communities Occupy Agricultural Ditches of Lake Erie Tributaries.**

We examined patterns in benthic macroinvertebrate communities in agricultural headwater streams and ditches in northwest Ohio. We hypothesized that recently dredged ditches from which accumulated sediments and aquatic and streamside vegetation had been removed would have low taxonomic richness and abundance, and successively increasing richness and abundance in following years. Taxonomic richness and abundance were sampled in June and August over multiple years in 20 1st-order ditches with perennial flow but no riparian vegetation that were dredged 0-10+ years prior to sampling. Richness and abundance of sensitive taxa were distinctly greater in ditches with remnant natural riffles compared to other ditches. However, proportion of sensitive taxa and total macroinvertebrate taxa richness were not correlated with years since dredging. The results showed that maintained agricultural ditches sustain taxonomically rich macroinvertebrate communities (45-81 taxa in individual ditches excluding midges and oligochaetes). Given the permanence of agroecosystems in Midwestern and Great Lakes landscapes, the question remains as to what comprises "optimum" or "ideal" macroinvertebrate community composition and abundance in agricultural ditches in terms of ecological functions and designated ecoregion reference conditions. *Keywords: Biodiversity, Agroecosystem, Distribution patterns, Macroinvertebrates.*

BOEHME, J.R.[1], WANG, L.[1], SERVEISS, V.[2], JARJOUR, J.[3], ARVAI, A.[1], BURROWS, M.J.[1], and WILSON, J.[1], [1]IJC Great Lakes Regional Office, 100 Ouellette Ave., 8th Floor, Windsor, ON, N9A 6T3; [2]IJC US Section, 2000 L Street, NW Suite #615, Washington, DC, 20440; [3]IJC Canadian Section, 234 Laurier Avenue West, 22nd Floor, Ottawa, ON, K1P 6K6. **Development and Definitions of Selected IJC Great Lakes Ecosystem Indicators.**

During the last two years, the International Joint Commission (IJC), recognizing the value of indicators for assessing the health of the Great Lakes, has undertaken the development of a focused set of apex ecosystem indicators. These ecosystem indicators will form one part of a science-based framework for assessing progress towards achieving the objectives of the Great Lakes Water Quality Agreement. In considering the vast amount of previous work available to inform the development of apex ecosystem indicators, the IJC's Science Advisory Board, Water Quality Board and experts from the United States and Canada have defined 16 ecosystem indicators for measuring physicochemical and biological integrity of the Great Lakes. This presentation provides examples of selected ecosystem indicators and describes both their scope and development. *Keywords: Indicators, Ecosystems, Water quality.*

BOHLING, M.E.[1] and LAPORTE, E.A.[2], [1]MSU Extension Sea Grant, 15100 Northline Rd, Suite 200, Southgate, MI, 48101; [2]Michigan Sea Grant, 520 E. Liberty, Suite 310, Ann Arbor, MI, 48104. **Education and Outreach of Habitat Restoration in the St. Clair Detroit River System.**

Ecosystems in the international waterways that flow between Lakes Huron and Erie have suffered greatly since the arrival of the first Europeans over 300 years ago.In the late 1800s and early 1900s, the waterways of the St. Clair-Detroit River ecosystem supported

large populations of lake sturgeon, whitefish and a highly profitable commercial fishery. Since then, fish and wildlife populations have declined as a result of dredging, overfishing and pollution. In 2004, a broad coalition came together to create relevant, new science to assist resource managers in making decisions concerning restoration of native aquatic species and their habitats in Lake St. Clair, Detroit and St. Clair Rivers. This international partnership includes federal, tribal, state, provincial, local and non-governmental participants. The main goal of the partnership is to restore and improve the ecological function and resilience of the St. Clair-Detroit River ecosystem. Michigan Sea Grant staff has contributed to the Initiative in a variety of ways since its inception, including public outreach (meeting facilitation and conference planning, and educational resource development), as well as research coordination and grant management of several fish spawning reef habitat construction projects.This presentation will focus on the education and outreach efforts *Keywords: Coastal ecosystems, Connecting waters, Environmental education, Outreach.*

BOSTON, C.M.[1], HOYLE, J.A.[2], and RANDALL, R.G.[1], [1]Fisheries and Oceans Canada, 867 Lakeshore Road, Burlington, ON, L9H 5G9; [2]Ontario Ministry of Natural Resources, Lake Ontario Management Unit, 41 Hatchery Road, Picton, ON, K0K 2T0. **Fish community structure in Hamilton Harbour: describing a fish community from a degraded ecosystem and comparison with other Areas of Concern in Lake Ontario.**

Hamilton Harbour (HH)was identified by the IJC in 1985 as an Area of Concern due to extensive aquatic habitat loss, cultural eutrophication, and high levels of contaminants found in sediment. Historically, HH was a productive wetland area that supported spawning and nursery habitat for many species of native fish and is still important to fish populations at the western end of Lake Ontario. As part of a RAP for HH, a nearshore fish community monitoring and assessment program using was established in 1988 by Fisheries and Oceans Canada. At the same time, an indicator of ecosystem health, the Great Lakes Index of Biotic Integrity, was developed to interpret the data and set quantitative targets for delisting. Over time, measures have been introduced to restore fish habitat, control invasive species and to assess water quality parameters and other programs were developed to assess the fish community. The objectives of this paper are threefold: assess the spatial and temporal trends in the nearshore fish community using indices of ecosystem health (e.g. IBI, PPB);compare the nearshore fish community of HH to other coastal areas in Lake Ontario and identify habitat variables that characterize the existing fish community. *Keywords: Hamilton Harbour, Ecosystem health, Fisheries.*

BOURBONNIERE, R.A. and MACKAY, D.R., Environment Canada, Water Science & Technology Directorate, Burlington, ON, L7R4A6. **Dissolved Greenhouse Gas Dynamics and their Relationship to Hypolimnetic Hypoxia in Lake Erie.**

Recent interest in the emissions and removals of greenhouse gases (GHGs) from terrestrial and aquatic environments has spurred research efforts in freshwater systems, both large and small. Concentrations of dissolved carbon dioxide ($CO_2$), methane ($CH_4$) and nitrous oxide ($N_2O$) were measured in all three basins of Lake Erie since 2009. Studies involved all-season surveys of the epilimnion and hypolimnion as well as dissolved GHG profiles. All three GHGs are related to dissolved oxygen concentrations in the lake. For the central basin, during late summer hypoxia, dissolved $CO_2$, $CH_4$, and $N_2O$ occur in higher concentrations than at any other location in the lake or at any other time. The inter-annual and spatial variability of dissolved GHGs, the occurrence of "hot spots" and "hot moments" for all three GHGs; as well as sediment-water and water-air fluxes for $CH_4$ will be presented. A changing climate may have implications for the frequency and duration of hypoxic/anoxic events in Lake Erie, and that will be reflected in the lake's changing GHG dynamics. *Keywords: Oxygen, Greenhouse gases, Carbon cycle, Biogeochemistry.*

BOURGEAU-CHAVEZ, L.L., BATTAGLIA, M.J., ENDRES, S.L., LAUBACH, Z.M., MILLER, M.E., and BANDA, E.C., Michigan Tech Research Institute, 3600 Green Ct., Ste. 100, Ann Arbor, MI, 48105. **Mapping the U.S. and Canadian Coastal Great Lakes Wetlands and Stressors.**

A project funded by the Great Lakes Restoration Initiative to produce an international contemporary baseline map of wetland type, extent and adjacent land use of the coastlines of the Great Lakes is nearly complete. For monitoring landscape scale indicators of wetland health and for planning the collection of field data in coastal ecosystems, a consistent and contemporary baseline map that crosses political borders is needed. The international wetlands map is being produced using a fusion of multi-season ALOS PALSAR L-band and Landsat data. Multi-seasonal data from these complementary sensors allows the detection and classification of not only generic wetland types and land use classes, but also detection of large stands of problematic plant species including *Phragmites australis and Typha* spp. The maps are produced with a Random Forests classifier using training data derived from field work and air photo interpretation. A randomly selected subset of training data is reserved for validation to evaluate map accuracy. The basin-wide maps will provide the first ever international Great Lakes coastal land-use land-cover map suitable for coastal wetland assessment and management. Long-term monitoring of coastal Great Lakes wetlands is needed for management and decision support to keep our Great Lakes ecosystems healthy. *Keywords: Phragmites australis, Landsat, Coastal wetlands, SAR.*

BOWEN, G.S. and CHOMICKI, K.M., Toronto and Region Conservation Authority, 5 Shoreham Dr, Downsview, ON, M3N 1S4. **Spatial and temporal variation in the water quality of four marshes adjacent to the nearshore of Western Durham, Lake Ontario.**

Western Durham coastal wetlands are examples of the general importance of the retention of sediments and cycling of nutrients originating from watersheds prior to waters entering Lake Ontario. In Western Durham, there are three drowned-river mouth marshes located by the outlets of the Rouge River, Duffins Creek, and Carruthers Creek, and one barrier beach lagoon marsh (Frenchman's Bay marsh) adjacent to the nearshore of Lake Ontario. These marshes range in size from 23 to 141 ha, and are the recipients of water draining watersheds between 27 and 333 $km^2$. Concurrent with a nearshore water monitoring program, the Toronto and Region Conservation Authority has measured water quality (e.g. total phosphorus, soluble reactive phosphorus, nitrate+nitrite) and E. coli at multiple locations within these marshes in the ice-off seasons from 2007-2009. This presentation will examine the spatial variation in water quality within and among the marshes, and explore seasonal differences in nutrient concentrations (e.g. nitrate+nitrite, ammonia, total phosphorus, and soluble reactive phosphorus). Additionally, linkages between marsh and lake nearshore water quality will be explored in relation to water levels in Lake Ontario. *Keywords: Coastal wetlands, Nutrients, Water quality.*

BOWEN, K.L.[1], JOHNSON, T.B.[2], CURRIE, W.J.S.[1], and KOOPS, M.A.[1], [1]Fisheries and Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6; [2]Ontario Ministry of Natural Resources, R.R. #4, 41 Hatchery Lane, Picton, ON, K0K 2T0. **Temporal Trends in the Zooplankton Community of Lake Ontario: Canadian Index Station Results Complement the CSMI Lakewide Surveys.**

The binational Lake Ontario CSMI surveys conducted seasonally in 2003, 2008 and 2013 provide good lakewide spatial coverage of many physical, chemical and biological parameters. While these studies emphasize spatial variation and can show long term changes, index stations that are sampled much more frequently fill in temporal gaps, both between CSMI years and within seasons. This is most critical for organisms with high turnover rates and periodic blooms, such as zooplankton. Here we will explore changes in the zooplankton community at station 81 in the Kingston Basin since the 1980s, and compare to CSMI results. Recent biweekly findings at several Canadian nearshore sites will also be compared to earlier surveys. For example, summer epilimnetic crustacean densities have declined more than 90% at Stn 81 since the 1990s, and cyclopoid copepods have been reduced to very low numbers. Dreissenid veligers are now a dominant zooplankter in the nearshore, especially in late summer. Some of these dramatic changes in the eastern Lake Ontario zooplankton community are likely due in part to competition with dreissenid mussels, changes in water clarity and predation by the invasive cladocerans *Cercopagis* and *Bythotrephes*. Potential changes in mean size and vertical distribution of zooplankton will also be explored. *Keywords: Zooplankton, Lake Ontario, Invasive species.*

BOWMAN, M.F., Forensecology, 70 Swift Crescent, Guelph, ON, N1E 7J1. **Forensecology: The application of a broad spectrum of sciences & technologies to investigate and establish facts related to ecology.**

The overarching goal of applied ecology is logically evolving from documenting the extent of environmental impacts to isolating specific environmental stressors. This evolution is essential for effective ecosystem management and restoration and is especially important in the face of evolving environmental stressors. As in traditional forensic science, there are numerous existing & potential Forensecology Indicators that could be used to untangle the effects of multiple stressors; both directly (e.g., chemical fingerprints) & indirectly (e.g., novel ways of thinking about issues). What is in our toolbox and what is missing? Just as important as the indicators themselves is organizing them in an accessible framework. The overall goal of Forensecology is to promote development of the novel indicators & frameworks we need to diagnose the precise cause(s) of existing & emerging environmental issues. *Keywords: Indicators, Ecosystem health, Priority pollutants.*

BOYER, G.L.[1], RADICELLO, R.M.[1], WATSON, S.B.[2], and WILHELM, S.W.[3], [1]Departments of Chemistry and Environmental Science, State University of New York, College of Environmental Science and Forestry, Syracuse, NY, 13210; [2]Ecosystems Management Research, Environment Canada, Canada Centre for Inland Waters, Burlington, ON, L7R 4A6; [3]Department of Microbiology, The University of Tennessee, Knoxville, TN, 37996. **Development of an Indicator for harmful algal blooms in the Great Lakes.**

Harmful Algal Blooms caused by Cyanobacteria (CHABs) impair drinking- and recreational waters in the Great Lakes through the production of toxins. Monitoring remediation efforts for these blooms is a challenge. Cyanobacteria are a normal component of the natural ecosystem and only a fraction of these blooms produce toxins. Blooms vary in toxicity, location, and the causative organism. Wind-blown scums produce shoreline toxin levels orders of magnitude higher than off-shore values. Most current monitoring efforts measure total algae or cyanobacteria as a surrogate for the harmful species, ignoring that remediation efforts may select for toxic or non-toxic species. Here we measured combinations of specific indicators including the cyanobacteria pigment phycocyanin, toxin-producing genes, and CHAB toxins in Chautauqua Lake (NY), Sodus Bay (Lake Ontario) and the western basin of Lake Erie; the latter two are locations of extensive US and Canadian CHAB remediation efforts. We found high spatial variance in cyanotoxin production, often uncorrelated with cyanobacterial abundance. In Sodus Bay, annual and late summer average CHAB toxicity decreased from 2010 to 2012 in the absence of remediation efforts. These results highlight the need to develop a robust indicator for CHABs to evaluate future remediation efforts. *Keywords: Cyanophyta, Lake Erie, Harmful algal blooms, Sodus Bay, Indicators.*

BOYLE, S.P., LITZGUS, J.D., and LESBARRÈRES, D., 935 Ramsey Lake Rd, Sudbury, ON. **Knowing Where They Cross: Using Hotspot Analyses to Inform Wildlife Management Decisions in a Provincial Park.**

Reptiles and amphibians are amoung the most threatened taxa on local and global scales. Roads, represent one of the most significant concerns with respect to herpetofauna conservation. Common techniques used to mitigate these negative effects are fencing to minimize access to roads and culverts to maintain permeability. Advance planning and data collection play critical roles in designing informed and effective mitigation. We used a 4 year-Before-After-Control-Impact-Paired study design to evaluate the effectiveness of proposed mitigation measures. Year 1 of surveys for herpetofauna took place May - September 2013 in Presqu'ile Provincial Park, before construction planning began. Multiple surveys were conducted daily in order to identify priority herpetofauna crossing points. Linear Ripley's K analyses were used on GPS waypoints in order to identify significant aggregations (hotspots) of herpetofauna road crossings. Hotspots were identified for all focal taxa. Hotspots varied spatially both within and between taxa. Identifying hotspots allows researchers and managers to predict the probable locations where focal species' would cross the road and assign resources accordingly. Data collected is being used to design a comprehensive mitigation strategy for the repaving of Presqu'ile PP's main road this fall. *Keywords: Reptiles, Road ecology, Conservation, Amphibians.*

BOZIMOWSKI, A.A.[1], KOURTEV, P.S.[1], MURRY, B.A.[2], and UZARSKI, D.G.[1], [1]Central Michigan University, Mount Pleasant, MI, 48859; [2]International Institute for Tropical Forestry, Jardin Botanico Sur, San Juan, PR, 00926, Puerto Rico. **Aquatic Macroinvertebrate Co-Occurrence Patterns in Great Lakes Coastal Wetlands: Interaction of the Harsh-Benign Hypothesis and Community Assembly Rules.**

Aquatic macroinvertebrate assemblages within Great Lakes coastal wetlands represent a community that may be governed by competition. According to the harsh-benign hypothesis, the intensity of competition increases as natural disturbance decreases. Modified effective fetch was used as a surrogate for wave action and a dominant indicator of natural disturbance within sites. Other abiotic parameters such as percent organic soil, vegetation type, and substrate type were also important in determining disturbance regimes. Yearly macroinvertebrate taxon data from 1999-2012 were reformulated into presence-absence matrices for harsh and benign sites and compared using the null model analysis program *EcoSim 700*. Species data were further separated and analyzed within functional feeding and taxonomic groups. The effects of predation by fish on macroinvertebate species co-occurrences were explored through exclosures. Competition in the form of significant negative co-occurrences between species was expected to appear in benign sites. Competition seen within functional feeding groups is consistent with resource competition; whereas competition within taxonomic group may be better explained on an evolutionary basis. Predation of macroinvertebrates by fish may also account for negative co-occurrences between species. *Keywords: Coastal wetlands, Community assembly, Macroinvertebrates, Disturbance, Predation.*

BRADLEY, A., On The Commons, 2104 Stevens Ave S, Minneapolis, MN, 55404. **The Great Lakes Commons Initiative - A Groundbreaking Collaboration to Transform the Future of our Lakes.**

The Great Lakes Commons Initiative emerged from the recognition that current governance is failing to protect our waters and communities. Decades of effort on behalf of the Great Lakes have not achieved their thriving future. A deeper systems level shift is needed, one that questions the underlying assumptions driving the current approach to stewardship and governance, and that fundamentally reorients toward a life-sustaining future. Both commons and Indigenous frameworks of eco-system governance offer complementary sources of knowledge and practice vital to solving our current challenges. Nobel Laureate Elinor Ostrom has shown the commons, and kindred indigenous practices, to be highly effective forms of stewardship whose governance is focused on multi-generational sustainability, shared responsibility and equitable benefit. The strength of the commons for the Great

Lakes is in its ability to orient us toward interdependence, to activate and enable broad leadership from throughout the bioregion and to affirm the value of our water as a source of life, not just a "resource." The Great Lakes Commons Initiative has catalyzed a cross-border, cross-sector network of scholars, community leaders, environmentalists, educators and cultural workers to learn, experiment and actualize a commons approach to our waters. *Keywords: Commons, Decision making, Great Lakes basin, Systems intervention, Public participation.*

BRAND, J.[1], BINNS, A.D.[1], and CRAWFORD, S.S.[2], [1]Western University, Department of Civil and Environmental Engineering, 1151 Richmond Street, London, ON, N6A 3K7; [2]University of Guelph, Department of Integrative Biology, 50 Stone Road East, Guelph, ON, N1G 2W1. **Hydrodynamic Effect on Rates of Entrainment of Ichthyoplankton at a Cooling Water Intake Structure in Lake Huron.**

Water usage industries with cooling water intake structures (CWIS) draw large volumes of water from the aquatic environment. This process can entrain ichthyoplankton from the water body. It is critical to be able to accurately estimate CWIS entrainment rates, since mortality caused by entrainment can have detrimental short- and long-term effects on wild fish populations and other aquatic biota. While hydrodynamic patterns are a known factor that affect entrainment, to date there have been few investigations of hydrodynamic effects on biological entrainment rates. This research seeks to characterize hydrodynamic patterns in the proximity of a CWIS operated by a nuclear generating station on Lake Huron. The intake structure is situated at a depth of 12-15m, and located 650m offshore. Hydrodynamic patterns were characterized with measurements sampled around the intake by surface-deployed acoustic Doppler current profilers in 2013. Results indicate: 1) an inverse relationship between velocity and distance from the intake; 2) complex bathymetric effects on currents; and 3) a disruptive effect of CWIS discharge on surface velocity near the intake. Results are directly applied to investigate the relationship between hydrodynamic patterns and the entrainment risk of lake whitefish (Coregonus clupeaformis) larvae in the source waters. *Keywords: Hydrodynamics, Biological entrainment, Environmental effects, Industrial water usage, Cooling water intake structure.*

BRAUN, H.A.[1], KOWALSKI, K.P.[2], and HOLLINS, K.M.[1], [1]Great Lakes Commission, 2805 S. Industrial Hwy, Suite 100, Ann Arbor, MI, 48104; [2]U.S. Geological Survey, 1451 Green Road, Ann Arbor, MI, 48105. **Great Lakes *Phragmites* Collaborative: A Partnership to Link People, Information and Action.**

The rapid progression of *Phragmites australis* (Common Reed) across the Great Lakes basin has affected the biodiversity and ecological functions of habitats, impaired the socio-economic value of wetlands and shorelines, placed an increased financial burden on land managers and threatens the extensive habitat restoration efforts funded through the Great Lakes Restoration Initiative. Resources on Phragmites management and research are scattered and sometimes inaccurate, and little coordination exists among stakeholders to guide management efforts. A coordinated approach to improve collaboration, communication and effectiveness of *Phragmites* management and research was initiated in 2012. The Great Lakes *Phragmites* Collaborative (GLPC) was established to facilitate regional communication and serve as a partnership to link people, information and action. The GLPC capitalizes on an interactive approach to facilitate access to rigorous science and promote network building among managers, government agencies, landowners and scientists. We present an overview of the organizational structure, goals and objectives of the GLPC, review the communications tools developed to date and discuss research and products under development to address knowledge gaps to improve coordination between scientists and managers. *Keywords: Management, Phragmites australis, Invasive species.*

BRETON, H., Hamilton Conservation Authority, 838 Mineral Springs Rd, Ancaster, ON, L0R 2H5. **The Living Infrastructure of Lower Spencer Creek - Restoring the Future.**

This presentation will focus on the work conducted through the Lower Spencer Creek Integrated Subwatershed Study. The first phase of this project built an inventory of existing information, developed an extensive monitoring program to supplement missing information, and subsequently developed a characterization of the watershed, subwatershed and stream reach condition. A multidiscipline approach was taken that included groundwater, surface water, water quality, fluvial geomorphology, terrestrial and aquatic assessments. Integration between disciplines was key to characterizing the natural systems. Simulations will be carried out to assess impact of future changes, the results of which will be used as input into a framework for implementation under the headings Planning and Policy, Rehabilitation and Retrofit, Stewardship, Monitoring, and Research and Development. The presentation will focus on the results of each of the study phases and discuss how findings were integrated using a multi-disciplinary approach to taking action to ensure a healthy sustainable subwatershed in the face of many present and future stresses. *Keywords: Ecosystem health, Integration, Environmental effects, Multi-disciplinery, Watersheds, Ecology.*

BRILAND, R.D., PFAFF, J.M., FARMER, T.M., and LUDSIN, S.A., Aquatic Ecology Laboratory - The Ohio State University, 1314 Kinnear Rd, Columbus, OH, 43212. **Recruitment of Invasive White Perch in Lake Erie: The Relative Roles of Climate Warming and Re-eutrophication.**

During recent decades, abundances of young-of-year (YOY) forage fishes have fluctuated widely in Lake Erie's western basin, with recent catches been dominated by invasive white perch (*Morone americana*). The mechanisms underlying this increase in white perch have yet to be explored, including the relative roles of increased inputs of bioavailable phosphorus from west basin tributaries and reduced winter duration (and concomitant early spring onset). We hypothesize that both changes would favor YOY white perch recruitment by increasing zooplankton prey production (via phosphorus inputs), lengthening the growing season (via an earlier spring onset), and increasing the size of the spawning population (via reduced overwinter mortality). Herein, we present findings from a statistical modeling exercise that used long-term (1985-2012) datasets of YOY white perch abundance, zooplankton length, biomass, and production, and physicochemical conditions to test our hypotheses and help elucidate the mechanisms underlying observed variation in YOY white perch abundance. *Keywords: Invasive species, Regime shift, Climate change, Phenology, Eutrophication.*

BRINSMEAD, J.K.[1], DROUIN, R.[2], FRENCH, R.[3], FRIESEN, T.[4], JOHNSON, T.B.[5], RITCHIE, B.[1], RODGERS, G.[3], and WRIGHT, E.[1], [1]Ontario Ministry of Natural Resources, 300 Water St., Peterborough, ON, K9J 8M5; [2]Ontario Ministry of Natural Resources, 659 Exeter Rd., London, ON, N6E 1L3; [3]French Planning Services Inc., 1016 Holiday Park Dr., Bracebridge, ON, P1L 1W9; [4]Ontario Ministry of Natural Resouces, 1 Stone Rd. W., Guelph, ON, N1G 4Y2; [5]Ontario Ministry of Natural Resources, 41 Hatchery Lane, Picton, ON, K0K 2T0. **Looking into the Crystal Ball: Forecasting AIS Science and Information Needs in Ontario Using the Delphi Method.**

While considerable aquatic invasive species (AIS) science and monitoring is being conducted in Ontario, there is also a perception that it does not provide all the information required by resource management and policy professionals to effectively prevent and manage AIS. Using the Delphi method, an iterative survey tool that helps build consensus on challenging topics based on input from a group of experts, we solicited input on AIS science and information needs from an expert panel comprised of resource management, policy and science professionals across Ontario. The panel was asked to forecast priority AIS and pathways for future management, types of information needed to inform future management, and solutions to effectively communicate science and information to resource management

and policy staff. By the end of the third iterative survey, a convergence of the panelists' opinions had occurred and consensus on a short list of priorities was achieved for many of the survey questions. These results will help agency and academic researchers address the information needs of resource managers in Ontario and adjacent jurisdictions. Observations on the use of and lessons learned about the Delphi method will be discussed. *Keywords: Delphi method, Aquatic invasive species, Information needs.*

BROOKS, C.N.[1], GRIMM, A.G.[1], SHUCHMAN, R.A.[1], SAYERS, M.[1], and AUER, M.T.[2], [1]Michigan Tech Research Institute, 3600 Green Ct., Ste. 100, Ann Arbor, MI, 48105; [2]Michigan Technological University, 1400 Townsend Dr., Houghton, MI, 49931. **Using a Satellite Time-Series Dataset to Analyze Growth of Cladophora and Other Submerged Aquatic Vegetation in the Great Lakes.**

Using Landsat imagery back to 1973, we have documented historic changes in the extent and distribution of submerged aquatic vegetation (SAV) in the lower four Great Lakes, showing decreases in SAV extent in most areas following the introduction of phosphorus targets to the Great Lakes Water Quality Agreement, with resurgence of SAV in the wake of the introduction of invasive mussels. We also captured the observed increases in water clarity in all four lakes over time. An MTRI algorithm helped produce maps of SAV in the nearshore zone of inland waters via an index that corrects for the effect of water depth for the lower four Great Lakes that are shallow enough to detect the lake bottom. Maximum mapping depth ranged from >20 m in Lake Michigan to 7 m in Lake Erie. This mapping approach has been validated for an overall map accuracy of 83%. Overall, the time series analysis indicates that the effects of invasive mussels on water clarity and phosphorus availability in the Lakes are enabling an increase in benthic SAV biomass, in deeper water than was previously possible, resulting in nuisance blooms of benthic vegetation even in areas without obvious local point sources of nutrients. These new maps will support *Cladophora* management efforts and help to prioritize areas for nutrient abatement programs. *Keywords: Cladophora, Satellite technology, Benthos.*

BROTHERS, S.M. and SIBLEY, P.K., University of Guelph, Bovey Building, Gordon St., Guelph, ON, N1G 2W1. **Long-Term Patterns in Primary Production in the Laurentian Great Lakes: Tracing the Cumulative Effects of Eutrophication and Invasive Species.**

A large number of studies have examined primary productivity in the Great Lakes over the past decades, yet to our knowledge there exists no comprehensive review which assesses the cumulative relationships between multiple stressors and primary productivity in these systems. While it has generally been assumed that increasing nutrient concentrations in lakes would boost whole-lake primary productivity by promoting phytoplankton production, benthic primary production in shallow zones (such as the west basin of Lake Erie) might have responded to eutrophication in more complex ways, depending upon the balance between light availability and nutrients (which have been influenced by invasive *Dreissena* since the early 1990's). It is thus feasible that shifts in food web dynamics may be partly the result of unexpected shifts in primary production. We examined this hypothesis by critically analyzing literature values of primary production from the 1960's to the present. Our results suggest that the relationship between nutrients and primary production has not been historically linear or consistent between lakes. We thus argue that Great Lakes ecosystems are subject to relatively complex patterns in primary productivity, an understanding of which may have important implications for future projections of local food web dynamics. *Keywords: Productivity, Phosphorus, Invasive species.*

BROWN, T., CAI, M., and REAVIE, E.D., Natural Resources Research Institute, UMD, 5013 Miller Trunk Highway, Duluth, MN, 55811. **Reconstructing Lake Superior landuse / landcover raster grids in yearly time steps from 1700 to present.**

Historical observations of levels of various types of landuse / landcover were associated with vector representations of their spatial extent at the time of observation. Spatial and temporal interpolation was used to generate grids representing intensity and distribution of each landcover type. Comparisons were made with diatom core data, but the technique's outputs have a wide range of possible applications. Observation database structure and GIS implementation are described. Expanding propagation fronts for widely distributed land uses such as first wave forestry were tested but found difficult to parameterize. Expanding polygons for higher intensity land uses such as open pit mining and urbanization were effective, but mining records and census data gave better temporal resolution. Point sources such as waste water treatment plants were also modeled. In addition to the core spatial and temporal interpolation components of the technique, data source (citation / metadata) tracking to tie input values to their sources is useful for model validation and defense. An automated method for summarizing land cover change in areas of interest (e.g. watersheds) was also developed to make the model outputs easier to integrate into subsequent analyses (e.g. diatom core comparisons). *Keywords: Spatial analysis, Paleolimnology, GIS.*

BUCK, B.S. and VAN OVERBEEKE, J.C., Carolinian Canada Coalition, 1017 Western Road, London, ON, N6G 1G5. **From Storytelling to Citizen Science: The Evolution of Carolinian Canada's *Grow Wild!* Species at Risk Outreach Program.**

Conservation outreach is exciting and challenging when promoting healthy habitats in a highly populated area like southwestern Ontario. Many plants and animals living here are little-known. The Pugnose Shiner, Green Dragon, Spiny Softshell and Round Pigtoe are just three of the 500+ rare species needing help. Our *Grow Wild!* program brings together smaller campaigns to address local priorities under a zone-wide outreach umbrella. It combines ecosystem science with social marketing - a concept gaining currency in the conservation world. We've promoted a series of habitat friendly pledges to measure success. These range from simply sharing a story to engaging in citizen science. Reaching our goal of 1000 pledges included a learning curve. We now have a web-based pledge to help local partners track success, a stronger virtual presence, attracted audiences beyond our traditional reach and linked to priorities identified by local Conservation Action teams. The process has generated a number of related projects and ideas including EcoTrails, Carolinian Canada Demonstration Sites and a youth Boot Camp. We've been happily surprised about the number of new partners wanting to be involved. For us, it underscores the need to try new appeal tactics, rejuvenate traditional interpretive approaches and address local habitat needs. *Keywords: Carolinian Life Zone, Conservation, Outreach, Conservation Action Plans, Community-based social marketing, Citizen science.*

BUCKLEY, J.D.[1], KOVALENKO, K.E.[2], GATHMAN, J.[3], and CIBOROWSKI, J.J.H.[1], [1]University of Windsor, 401 Sunset Ave, Windsor, ON; [2]Natural Resource Research Institute, 5013 Miller Trunk Highway, Duluth, MI; [3]University of Wisconsin - River Falls, 410 S 3rd St, River Falls, WI. **Assessing the Accuracy of Fish-Based Biological Indices as Indicators of Wetland Condition at The Great Lakes Coastal Margins using Receiver-Operator Characteristic Curve Analysis.**

Indicators are used to quantify and evaluate the condition of Great Lakes coastal wetlands. Accurate and reliable indicators are essential for both management and policy decision making. Biological indices have many benefits over other metrics as they quantify condition at a level that is relevant to managers and stakeholders of coastal wetlands. Currently, there are multiple fish-based biological indices; however, before these models can see widespread use, they must first be verified and validated with independent data. Three fish-based biological indices: the Uzarski Index of Biotic Integrity (Uzarski et al 2005), the Wetland Fish Index (Seilheimer & Chow-Fraser 2007) and the Fish Quality Index (Bhagat & Ci-

borowski, in development) were tested to determine which are able to accurately and consistently assess the condition of Great Lakes coastal margin sites. Through collaboration with the Great Lakes Environmental Indicators (GLEI) and Great Lakes Coastal Wetland Monitoring (GLCWM) projects, we sampled the fish communities and water quality of sites across the entire Great Lakes during the summers of 2011, 2012 and 2013. I use ROC analysis to test the ability of each of these indicator models in classifying sites as degraded across a variety of stressors. *Keywords: Indicators, Great Lakes basin, Fish.*

BUCKLEY, J.T.[1], GALAROWICZ, T.L.[1], CHADDERTON, W.L.[2], CLARAMUNT, R.M.[3], and HERBERT, M.E.[2], [1]Central Michigan University, Mount Pleasant, MI, 48859; [2]The Nature Conservancy, 1400 E. Angela Blvd., Unit #117, South Bend, IN, 46617; [3]Michigan Department of Natural Resources, 96 Grant St., Charlevoix, MI, 49720. **Monitoring Invasive Rusty Crayfish on Critical Lake Michigan Spawning Reefs.**

Restoring habitat and combating invasive species are two of the many goals of the Great Lakes Restoration Initiative. The Rusty Crayfish is a veracious egg predator that outcompetes native species along with depleting native fish egg survival. Our objective was to monitor seasonal densities of the invasive Rusty Crayfish on three native fish species (Lake Trout, Whitefish, and Cisco) spawning reefs located in Grand Traverse and Little Traverse Bays, Lake Michigan. Rusty Crayfish densities were measured by monthly scuba diving quadrate sampling surveys from May to December 2013, coupled with a mark and recapture study during August and September 2013. In fall 2013, Rusty Crayfish were removed on several of the reefs using scuba divers and baited tangle nets to capture crayfish. The quadrate surveys showed an increase in Rusty Crayfish densities in early fall across all reefs followed by a decries in density at the start of winter. The scuba diving removal captured over 2000 Rusty Crayfish, however it did not have an impact on Rusty Crayfish densities. Potentially this study can inform managers about Rusty Crayfish ecology and improve possible reef restoration control efforts in the future. *Keywords: Lake Michigan, Rusty Crayfish, Invasive species, Distribution patterns.*

BUCKNER, K.[1], READ, J.[2], SEELBACH, P.[3], and EDER, T.[3], [1]Council of Great Lakes Industries, 3600 Green Ct, Suite 710, Ann Arbor, MI, 48105; [2]University of Michigan Water Center, 214 S. State St., Suite 200, Ann Arbor, MI, 48104; [3]Great Lakes Commission, 2805 S Industrial Hwy, Suite 100, Ann Arbor, MI, 48104. **Collaborative Planning for Systems-level Monitoring and Accounting of Basin Water Resources.**

In response to a 2013 resolution by the Council of Great Lakes Governors, the Great Lakes Commission formed a collaborative workgroup to develop a comprehensive, systemic program for monitoring and accounting of basin water resources. The program is intended to support bi-national management efforts including the Great Lakes-St.Lawrence Water Resources Compact (water quantity) and the Great Lakes Water Quality Agreement, and to provide critical information for the development of economic and social policy in the region. The workgroup stepped back to consider the entire water resources system and how existing monitoring efforts align and contribute to the overall needs. March 2014 recommendations to the Council of Great Lakes Governors are anticipated to include: 1) establishing a common spatial framework for water resources information; 2) establishing a shared governance structure for basin information management; 3) tactical implementation of monitoring for critical information needs that drive desired water-based societal outcomes; and 4) active engagement of water stakeholders in monitoring, accounting for, and valuing the region's unparalleled resources. We will describe the collaborative process used to develop the monitoring and accounting system, and the program recommendations. *Keywords: Monitoring, Water resources, Regional analysis.*

BUNNELL, D.B.[1], WARNER, D.M.[1], ARMENIO, P.M.[1], CHRISCINSKE, M.A.[1], DAVIS, B.M.[1], KEELER, K.M.[1], NALEPA, T.F.[2], O'BRIEN, T.O.[1], VANDERPLOEG, H.A.[3], VINSON, M.R.[4], WATSON, N.M.[1], WOELMER, W.M.[1], and YULE, D.L.[4], [1]USGS Great Lakes Science Center, Ann Arbor, MI; [2]University of Michigan, Ann Arbor, MI; [3]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI; [4]USGS Great Lakes Science Center, Ashland, WI. **Describing Nutrients and Biomass Along a Nearshore to Offshore Gradient in Lake Huron with Comparisons to Lakes Michigan and Superior.**

Invasive species have been hypothesized to alter internal nutrient cycling in the Laurentian Great Lakes through conceptual models including the "nearshore shunt" and "mid-depth sink". We sampled five nearshore to offshore transects spanning lakes Huron, Michigan, and Superior to evaluate whether nutrients or biomass of flora and fauna declined with increasing depth (consistent with sequestration of allochthanous nutrients nearshore by dreissenid mussels). Preliminary analyses indicate that in most transects, biomass of zooplankton and fish can be just as high offshore (e.g., >80 m) as nearshore (e.g., ~15 m). We will interpret our results in the context of 1) existing conceptual models, and 2) the dramatic food web changes that have occurred in Lake Huron since the early 2000s. *Keywords: Nutrients, Invasive species, Fisheries.*

BURLAKOVA, L.E.[1], KARATAYEV, A.Y.[1], PENNUTO, C.M.[1], and MAYER, C.M.[2], [1]Great Lakes Center, SUNY Buffalo State, 1300 Elmwood Ave, Buffalo, NY, 14222; [2]Department of Environmental Sciences and Lake Erie Center, University of Toledo, 2801 West Bancroft St., Toledo, OH, 43606. **Changes in Lake Erie benthos over the last 50 years: historical perspectives, current status, and main drivers.**

During the last 50 years the ecosystem of Lake Erie has experienced major environmental changes, from anthropogenic eutrophication in 1930-1960s, to nutrient and pollution abatement in the 1970s, and then the introduction of exotic dreissenids in the 1980s. We used multivariate statistical techniques to examine long-term changes in the zoobenthic community, comparing contemporary collections (2009, 2011-2012) and historical data (1963-1965, 1978-1979, 1993, and 1998). The Lake Erie benthic community underwent significant changes during each decade examined, showing signs of recovery following ecosystem restoration in the 1970s, but then experiencing major structural and functional changes after dreissenid (*Dreissena polymorpha* and *D. r. bugensis*) introductions. There was a significant temporal trend in community composition changes from 1963 to 2012, and the largest difference was found between pre- and post-dreissenid invasion communities. Currently the lake-wide benthic community is dominated by dreissenids both in density (41%) and total wet biomass (97%), followed by oligochaetes and chironomids. The number of exotic species found in benthic surveys increased every decade, and their impact has had enormous consequences for the whole ecosystem. *Keywords: Benthos, Dreissena, Lake Erie.*

BURNET, S.H.[1], SCOFIELD, A.E.[1], WATKINS, J.M.[1], RUDSTAM, L.G.[1], and BARBIERO, R.P.[2], [1]Cornell Biological Field Station, 900 Shackelton Point Road, Bridgeport, NY, 13030; [2]CSC, 1359 W. Elmdale Ave. #2, Chicago, IL, 60660, United States. **Dynamics of the deep chlorophyll layer (DCL) across the Great Lakes.**

The Great Lakes are becoming more oligotrophic, influencing the formation of the deep chlorophyll layer (DCL). This process may impact the bioenergetics of organisms that rely on the DCL and alter the overall trophic functioning of the lakes. Summer survey data products from the Great Lakes National Program Office (GLNPO) of the US Environmental Protection Agency (EPA) include information on the thermal structure and vertical distribution of chlorophyll-a in all five lakes. Preliminary results for August 2013 demonstrate that extracted chlorophyll within the DCL was lowest in Lakes Huron, with Michigan and Superior somewhat higher (0.99 ug/L ± 0.13 SE; 1.57 ug/L ± 0.16 SE; 1.55 ug/L ± 0.14 SE respectively). DCL chlorophyll levels for Lake Ontario and eastern Lake Erie were nearly two times higher (3.07 ug/L ± 0.64 SE; 2.50 ug/L ± 0.37 SE respectively). Comparisons to

earlier GLNPO data may improve our understanding of the mechanisms determining DCL depth and monitor potential changes in its importance relative to surface primary production. *Keywords: Primary production, Deep chlorophyll layer, Water quality.*

BURROWS, M.J., IJC Great Lakes Regional Office, 100 Ouellette Ave, Windsor, ON, N9A 6T3. **Delivering Great Lakes Assessment Information.**

There is no question about the importance of Great Lakes ecosystem indicators, human health indicators and program effectiveness indicators to assess progress and identify sound management options. This fact is reflected in the large number of projects and proposals regarding effective new ways to manage data and process it into information that clearly translates to action. In 2013 at least 50 initiatives and over 60 programs were aimed to serve management needs. Geospatial services have provided the technology to deliver observations and information in a wide variety of spatial and temporal frames to benefit both local watershed and regional Great Lakes resource conservation. The Great Lakes Observing System (GLOS), Integrated Ocean Observing System and the Global Earth Observing System of Systems (GEOSS) are key elements of a sustainable tool for data discovery and use. Collecting, processing and effectively delivering key indicators and Great Lakes assessment information requires a common understanding of current initiatives, user needs and a high degree of collaboration. Key programs and initiatives, including GLOS, the GEOSS Great Lakes testbed, the Great Lakes Aquatic Habitat Framework, agency efforts and IJC indicators work will be discussed as well as opportunities to integrate key functions to deliver information. *Keywords: Indicators, Data storage and retrieval, Decision making.*

BUTTS, E.[1], FRAZIER, C.[1], VANDERPLOEG, H.A.[2], and CARRICK, H.[1], [1]Dept of Biology & IGLR, Central Michigan University, Mount Pleasant, MI, 48859; [2]Great Lakes Environ. Research Lab., National Oceanic and Atmospheric Administration, Ann Arbor, MI, 48109. **Changes in the Lake Michigan Food Web: Importance of microzooplankton 1980 to present.**

Changes in biomass and composition have been observed in the microbial food web of Lake Michigan. This study compares data from the 1980's to recent studies (2012-2013) on phototrophic and heterotrophic microzooplankton and ciliates. These changes are significant given the amount of time in which these changes have occurred. Is anthropogenic stress accelerating these changes to the microbial food web? *Keywords: Carbon cycle, Food chains, Plankton.*

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CALDER, M.S.[1], ZHAO, Y.[2], and ZOU, X.[1], [1]Department of Applied Mathematics, University of Western Ontario, 1151 Richmond Street, London, ON, N6A 5B7; [2]Aquatic Research and Development Section, Ontario Ministry of Natural Resources, 320 Milo Road, Wheatley, ON, N0P 2P0. **Amplification of the Net Reproductive Number By Dispersion for the Invasive Round Goby Fish.**

We will present a matrix population model which is applicable to the invasive round goby fish spread over multiple patches in the Great Lakes. The global net reproductive number quantifies the average number of offspring for an average newborn over their entire lifetime. Consequently, if this number is greater than one then the population will grow and if this number is less than one then the population will decline. With this model, we will address the question of whether or not dispersion can amplify the global net reproductive number compared to the global net reproductive number of the global system in the absence of dispersion. As we will see, the combined dispersion of both the larvae and juveniles can in fact amplify the net reproductive number. Experimental results will be included. *Keywords: Round goby, Fish populations, Invasive species.*

CAMPBELL, A.J., BECHLE, A.J., and WU, C.H., University of Wisconsin, 1261 Engineering Hall, 1415 Engineering Drive, Madison, WI, 53706. **A Cost Effective Remote Stereo Imaging System for Surface Wave Measurement.**

Remote stereo-imaging, a measurement technique based upon multiple overlapping camera views of the water surface, is an effective method for measuring surface waves. In this talk an innovative and cost effective Wide-baseline Stereo Imaging System (WSIS) will be presented. The spatial nature of WSIS provides advantages over previous *in situ* wave measuring techniques (e.g. wire wave gauges) as it can capture both the spatial and temporal characteristics of waves. The large coverage area of WSIS also allows for measurements of wavelength, directionality, and wave dispersion in many environmental conditions (e.g. in the presence of surface ice). Field measurements containing boat wakes, wind-generated waves, and ice-waves in Lakes Michigan and Superior will be presented. Wave height and wavelength measured by WSIS are also compared to those measured using wire wave gauges. Overall, WSIS proves to be an effective technique for remotely monitoring surface waves in lakes/oceans. *Keywords: Waves, Measuring instruments, Remote sensing.*

CANNING, R.A. and SAGER, E., Trent University, 1600 West Bank Drive, Peterborough, ON, K9J 7B8. **The Introduction and Management of *Stratiotes aloides* in the Trent-Severn Waterway.**

In 2008, the invasive macrophyte, *Stratiotes aloides*, was discovered within the Trent-Severn Waterway in Ontario. Despite this being the first known occurrence of this plant within a natural ecosystem in North America, it is recognized as a noxious weed and a prohibited aquatic plant species within the United States and among several other countries. In few short years, *Stratiotes aloides* has become one of the most dominant macrophytes in the part of the river where it was introduced, outcompeting native aquatic plant communities. Besides non-native macrophyte competition, fish and macroinvertebrate habitat, waterway navigation and recreational opportunities are all at risk following the arrival and spread of this invasive aquatic plant. The connected nature of the Trent-Severn Waterway also poses risks for transmission into the Bay of Quinte and Lake Ontario. The objective of this study is to determine the efficacy of using chemical and physical treatments for the control of *Stratiotes aloides*, while developing a management plan that both eradicates the plant and promotes the highest degree of native macrophyte recovery post-treatment. Control will be applied outside of peak biomass periods to limit the negative effect towards desirable non-target vegetation. *Keywords: Invasive species, Herbicide, Management.*

CAPELLE, P.M., MCCALLUM, E.S., and BALSHINE, S., McMaster University, 1280 Main Street West, Hamilton, ON, L8S 4L8. **Aggression and sociality: Conflicting or complementary traits of a successful invader?**

Invasion biology research has revealed two juxtaposing behavioural traits, aggressiveness and sociality, that may both increase the success of invasion. Aggression can help an invading species out-compete other species for resources, while being social can allow a species to tolerate high conspecific densities. In order to tease apart the impacts of these seemingly conflicting behaviours on the success of invasive species, we studied round goby (*Neogobius melanostomus*), a highly successful invasive fish species in the Laurentian Great Lakes. While round goby are known for being aggressive, less is known about their social tendencies, despite the fact that they thrive in extremely high densities. We collected round goby from Hamilton Harbour, ON, Canada, and looked at group-forming behaviour by measuring preference for a single conspecific versus remaining alone, preference for small versus large groups, and preference for a conspecific versus a shelter. We found that round goby have a strong preference to associate with a conspecific, but this preference is not modulated by group size. Females chose the safety of shelter over safety in numbers, while males did not show this preference. Our results provide new insight into the roles of aggressive and social behaviours in the rapid spread of invasive round goby. *Keywords: Round goby, Behaviour, Invasive species.*

CARRICK, H.[1], DANIELS, D.[1], FEHRINGER, M.[2], BUTTS, E.[1], CAFFERTY, E.[3], FAHNENSTIEL, G.L.[3], and VANDERPLOEG, H.A.[4], [1]Dept of Biology & IGLR, Central Michigan University, Mount Pleasant, MI, 48859; [2]Dept. of Biology, Nebraska Weslyan College, Lincoln, NE; [3]Great Lakes Research Institute, Michigan Technological University, Houghton, MI, 49931; [4]Great Lakes Environ. Research Lab., National Oceanic and Amospheric Administration, Ann Arbor, MI, 48109. **Plankton size structure from Near to Offshore: Contrasting Patterns in Lakes Michigan and Superior.**

Since 2005, unprecedented changes in the open water region of southern Lake Michigan have been observed and documented (see Fahnenstiel et al. 2010). These remarkable changes appear to be confined to the late winter to spring period, such that the typical diatom bloom that normally occurred at this time, is now gone. Here, we compare the biomass, taxonomic composition, and size distribution for phytoplankton and components of the microbial food web (algae and protoza) from data collected during two periods: 1980's (pre-dresseid mussels) and 2011 (post dresseid mussels). Our data shows an overall decline in phytoplankton biomass and a shift towards dominance by smaller-sized species from pre to post-mussel periods. A large decline (>50%) in phytoplankton biomass was observed in 2011 compare with 1983-87. The recent shift towards smaller species was reflected in a doubling of chlorophyll in the <2 um category (change from 25% to 50%). While biomass of microzooplankton was similar between periods, the assemblage appears to have shifted towards dominance by smaller species (flagellates and small cilitates), particularly in the spring. These data suggest that in Lake Michigan, traditional trophic link between diatoms and crustacean zooplankton has been replaced (in part) by the link between small phytoplankton and protozoa. *Keywords: Carbon cycle, Distribution patterns, Phytoplankton.*

CASAS-MONROY, O., LINLEY, R.D., and BAILEY, S.A., GLFFAS, Fisheries and Oceans Canada, 867 Lakeshore Rd., Burlington, ON, L7R-4A6. **Efficacy of Ballast Water Treatment Technologies in Context of Adapting to a Warming Arctic Environment.**

Currently, ballast water exchange is the only method widely utilized to reduce the risk of ballast-mediated nonindigenous species (NIS) introductions. Ballast water exchange replaces high-risk organisms from coastal environments with low-risk open-ocean organisms, but it is not 100% effective. Canada will soon strengthen ballast management requirements, having ratified the International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004. Under this convention, vessels will need to install a Ballast Water Management System (BWMS) in order to meet ballast water discharge standards. Concerns have arisen that some BWMSs may not operate as expected in cold or freshwater environments, particularly in the Arctic and Great Lakes. To better understand the effect of temperature on ballast water treatment processes, we examine the effectiveness of chemical (chlorine) and physical (UV-C irradiation) treatments at different temperatures on phytoplankton and zooplankton populations. Results so far revealed that a 2 ppm chlorine concentration at 10°C exterminated 80% of zooplankton organisms, while for phytoplankton the EC50 was calculated as 1ppm chlorine concentration at the same temperature. Grow out experiments also revealed that phytoplankton organisms were not able to reproduce after UV treatment. *Keywords: Biological invasions, Ballast, Plankton.*

CATLING, P.M., MITROW, G., and WARD, A., Agriculture and Agri-Food Canada, Saunders Bldg. 49, Central Experimental Farm, Ottawa, ON, K1A 0C6. **The *Phragmites* database: New information on the spread, potential distribution, habitats, identification and problems with European Common Reed in the Canadian portion of the Great Lakes and across Canada.**

The Canadian Phragmites database produced by Agriculture and Agri-Food Canada is a co-operative project of 22 government departments, museums and universities across Canada. It provided a wealth of information for a series of articles on the invasive alien European Common Reed (*Phragmites australis* subsp. *australis*) up to 2010. Since then the database has grown and now contains 1992 specimen records. Analysis of the database for this recent period and comparison with earlier maps has indicated recent expansion of the invasive alien subsp. in the Great Lakes drainage and in the prairie region of Canada. It is expected to reach the southern portions the Lakes Winnipeg and Manitoba as well as the irrigation districts of southern Alberta within a decade. Increasingly, there are occurrences of the plant on Great Lakes beaches, both sand and gravel, as well as in moist habitats and deep water. In beach situations it seriously interferes with beach flora and fauna, including nesting turtles and amphibian habitat, as well as reducing recreational opportunities and value of beach-front property. A larger and geographically broader sample of specimens has contributed to increased confidence in distinguishing the introduced subsp. *australis* from the native subsp. *americanus*. *Keywords: Environmental effects, Phragmites australis, Invasive species.*

CEJUDO, E., ARAVENA, R.O., and SCHIFF, S.L., University of Waterloo, EIT, 200 University Ave. West, Waterloo, ON, N2L 3G1. **Before and after: the effect of Kitchener wastewater Treatment plant upgrade in Dissolved Inorganic Nitrogen in the Central Grand River.**

The present research examines river geochemistry before, during and after upgrades in one of the primary wastewater treatment plants in the Grand River watershed. Recent upgrades to the Kitchener wastewater treatment plant (KTP) resulted in significant changes in the Dissolved Inorganic Nitrogen (Total Ammonia Nitrogen and Nitrate) loading to the Grand River. The primary reason for upgrades was to shift from a non-nitrified to a nitrified effluent, thus reducing oxygen demand below the treatment plant. During 2013, the raw effluent underwent change in Total ammonia Nitrogen ($NH_3$+$NH_4^+$) to less than 0.5 mg TAN/L; while $NO_2^-$+$NO_3^-$ increased to ≥30 mg/L. Differences in the quality of the effluent can also be observed in the nitrogen isotope composition of the periphyton in areas immediately downstream KTP. Although both winter (high dissolved oxygen, low temperature) and summer (high temperature, low dissolved oxygen) periods are critical in the overall metabolic status of the Grand River, sampling efforts were focused on summer, low flow conditions. This sampling regime was chosen in order to best assess the extent of the effluent plume and its daily oscillation, and to allow documentation of the impact of transitioning to a nitrifying plant. *Keywords: Water quality, Nutrients, Periphyton, Isotope studies.*

CHAFFIN, J.D., REUTTER, J.M., WINSLOW, C.J., THOMAS, M.A., STANFORD, K.M., and HART, K.W., F.T. Stone Laboratory, Ohio State University, PO Box 119, Put-in-Bay, OH, 43456. **Renovations to Stone Laboratory Increase Research Opportunities.**

Renovations to Stone Laboratory, part of Ohio State University and located on South Bass and Gibraltar Islands in Lake Erie, have improved the lab's research capabilities and offers visiting scientists a greater opportunity to conduct research on the islands and western Lake Erie. The wet lab includes aquariums of all sizes up to 250-gallon flow-through systems. Overhead compressed air and lake water combined with an open floor plan provide flexibility for aquatic experiments. The analytical lab is equipped with a nutrient autoanalyzer, -80C freezer, refrigerated centrifuge, spectrophotometer, drying ovens, and other equipment. Bench space is available in both labs. Field equipment available include YSI sondes, nets for fish, plankton, and invertebrates, various water samplers, underwater cameras, remotely operated vehicle, side scan and multi-beam sonars, and NWMT wire tagging and radio telemetry tracking equipment. A weather data buoy will be deployed near the islands early summer 2014. Four research vessels are capable of deploying heavy equipment, fish trawls, and long-distance sampling. Housing and meals are available and wireless internet services all Stone Lab's buildings and grounds. Please contact Justin Chaffin (chaffin.46@osu.edu) for more information about research opportunities at Stone Lab. *Keywords: Lake Erie, Field Station, Research.*

CHAU, J., EcoSpark, 1179 King Street West, Suite 114, Toronto, ON, M6K 3C5. **Engaging Youth and Adults in Water Quality and Quantity Monitoring in Watersheds along the north shore of Lake Ontario.**

EcoSpark, an environmental charity, has been leading citizen science programs across southern Ontario since it was founded in 1996. Our most recent water-based citizens science programs include Changing Currents (engaging youth in water quality monitoring using benthos) and Check Your Watershed Day (engaging adults in monitoring baseflow). To date, these programs have spanned to over 20 watersheds across southern Ontario, the majority of which are along the north shore of Lake Ontario. This presentation will compare these two citizen science programs, e.g., adult-based monitoring on a geographic landscape (the Oak Ridges Moraine) versus youth-based monitoring sites based on school locations. This presentation will cover the data collected from each program, as well as impact of the programs from the perspectives of education, data collection, informing policy and influencing decision-making. It will also cover the challenges between balancing education and science, and sustaining engagement over time. Lastly, there will be an overview of the key elements that enabled these programs to be successful and their potential for improvement and expansion. *Keywords: Citizen science, Baseflow, Benthos, Lake Ontario, Education.*

CHIANDET, A.S. and SHERMAN, R.K., Severn Sound Environmental Association, 67 Fourth, Midland, ON, L4R 3S9. **Why are phytoplankton communities different in Severn Sound, Georgian Bay?**

The open water and sheltered bays of Severn Sound, Georgian Bay are being studied to investigate factors affecting phytoplankton communities in an area of diverse physico-chemical characteristics. Following significant reductions in TP loads and the establishment of Dreissenids in the mid 1990's, concentrations of TP in the open waters of Severn Sound declined dramatically. Total algal biovolume also declined, and community composition shifted to include a greater portion of mixotrophic algae, particularly chrysophytes. Using microscope count data from euphotic zone composite samples and Fluoroprobe profiles collected from 2011-2013 for open water and nearshore stations, we demonstrate that patterns in phytoplankton typical in other parts of the Great Lakes do not always apply in Severn Sound. Cyanophytes have been noticeably uncommon in the phytoplankton community, with the exception of South Bay, a small sheltered bay in the Honey Harbour area where TP concentrations are highest and have not changed significantly since 1981. Pigment profile data showed differing vertical patterns in the phytoplankton that can be explained by a combination of factors including thermal stability. *Keywords: Thermal stability, Phosphorus, Fluoroprobe, Phytoplankton, Georgian Bay.*

CHIN, A.T.M.[1], TOZER, D.C.[2], FRASER, G.S.[1], and WALTON, N.G.[3], [1]York University, 4700 Keele Street, Toronto, ON, M3J 1P3; [2]Bird Studies Canada, P.O. Box 160, 115 Front Street, Port Rowan, ON, N0E 1M0; [3]University of Wisconsin-Green Bay, 2420 Nicolet Drive, Green Bay, WI, 54311. **Comparing Bird-based Disturbance Gradients and Indices of Biotic Integrity for Ranking the Health of Great Lakes Coastal Wetlands.**

Indices of biotic integrity (IBIs) are important tools for assessing ecosystem health and have been developed for use in Great Lakes coastal wetlands using bird community data. However, the relative performance of IBIs for this purpose is unknown. We compared scores calculated with three bird-based IBIs, the Index of Marsh Bird Community Integrity (IMBCI), the Index of Biotic Integrity (IBI), and the Index of Ecological Condition (IEC), using the same bird community dataset. IBI and IEC require defining a landscape disturbance gradient to calculate scores, which resulted in different scores and ranks of wetland health based on the method of calculating gradients. Scores mostly corresponded between each of the three IBIs (all $r \leq 0.671$). By contrast, ranks of each wetland from least healthy to most healthy were highly dependent on the index chosen, differing by 24 to 50 positions out of 143 wetlands, on average, depending on the pair of IBIs chosen. However, scores from all three of the IBIs were correlated with at least one of the disturbance gradients. Thus, despite lack of agreement among the IBIs, each appeared to be capturing useful albeit different information about wetland health. We suggest proceeding cautiously when choosing landscape disturbance gradients and IBIs for assessing Great Lakes coastal wetland health. *Keywords: Citizen science, Coastal wetlands, Indicators.*

CHIU, C.M.[1] and HAMLET, A.F.[2], [1]University of Notre Dame, 1400 E. Angela Blvd, South Bend, IN, 46617; [2]Dept. of Civil and Environmental Engineering and Earth Sciences, University of Notre Dame, 156 Fitzpatrick Hall, Notre Dame, IN, 46556. **A century long grid-**

**ded hydrometeorological dataset for assessing the impacts of climate variability and climate change on the Great Lakes region.**

Climate change is likely to impact the Great Lakes region via changes in Great Lakes water levels, agricultural applications, river flooding, urban stormwater impacts, drought, water temperature, and terrestrial and aquatic ecosystem processes. Self-consistent and temporally homogeneous long-term data sets of precipitation and temperature over the entire Great Lakes region (U.S. and Canada) are needed to provide inputs to hydrologic models, assess historical trends in hydroclimatic variables, and downscale global and regional scale climate models. To support these needs a gridded meteorological forcing dataset at 1/16th degree resolution incorporating both temporal and topographic adjustments has been assembled over the Midwest region from 1910-2013. These data were then used as inputs to the macro-scale Variable Infiltration Capacity (VIC) hydrology model to produce derived hydrologic variables that are amenable to long-term trend analysis. Independent validation of the meteorological driving data set has been carried out using macro-scale simulations of streamflow from the VIC model compared with streamflow observations in the U.S. and Canada. Trends in precipitation and temperature as well as simulated hydrometeorological variables such as snowpack, soil moisture, and evaporation over the 20th century are discussed. *Keywords: Model studies, Great Lakes basin, Climatic data.*

CHOI, J.M.[1], TROY, C.D.[1], MCCORMICK, M.J.[2], HAWLEY, N.[3], and WELLS, M.G.[4], [1]Purdue University, School of Civil Engineering, West Lafayette, IN, 47907-2051; [2]University of Michigan, Cooperative Institute for Limnology and Ecosystems Research, Ann Arbor, MI, 48109-1041; [3]Great Lakes Environmental Research Laboratory, NOAA, Ann Arbor, MI, 48108-9719; [4]University of Toronto, Physical and Environmental Sciences, Toronto, ON, M1C 1A4. **Drifter and dye release experiments in internal Poincare wave-dominated southern Lake Michigan.**

Internal Poincaré waves are considered as important sources that enhance lateral dispersion in stratified southern Lake Michigan. The near-inertial kinetic energy from Poincaré waves dominates the spectrum during the stratified period, and the strong shear induced by the near-inertial currents is shown to be associated with enhanced lateral dispersion through a mechanism of unsteady shear flow dispersion. The internal Poincaré waves are investigated in terms of the vertical structure of shear and temperature, and the vertical eddy diffusivity over the mixed layer is examined using microstructure data and turbulence model results. Results suggest that turbulent mixing and dispersion over the mixed layer can be broken into two relatively distinct stratification regimes. Both drifter and dye release experiments from

Lake Michigan are used to demonstrate the important role of vertical shear induced by Poincaré waves on lateral dispersion. A data-driven particle tracking model is performed to quantify the elevated horizontal dispersion caused by the waves, and a simple empirical model is proposed to quantify the elevated dispersion. *Keywords: Lake Michigan, Internal Poincare wave, Drifter and dye experiments.*

CHOMICKI, K.M., BROWN, C.J.M., and BOWEN, G.S., Toronto and Region Conservation Authority, 5 Shoreham Dr, Downsview, ON, M3N 1S4. **Annual and seasonal differences in nearshore water quality of Lake Ontario by Western Durham in relation to wet and dry years.**

Water quality in the nearshore (NS) can be affected by tributary loading, which changes on a seasonal basis. Understanding NS water quality patterns and drivers is important as this is a region where the public interacts with the lake, and where drinking water is drawn from. Despite this, few longitudinal studies from the same site with spatial resolution exist which examine the relationships between water quality, seasons, and relationships with wet and dry years. In addition to calculating tributary loading, the Toronto and Region Conservation Authority has been monitoring NS water quality in the Western Durham region of Lake Ontario since 2007, analyzing nutrients such as SRP, TP, and nitrate+nitrite. The monitoring area is near the Pickering Nuclear Generating Station and the outfall to the Duffin Pollution Control Plant (DPCP)- the 3rd largest control plant on the Canadian shores of Lake Ontario. Higher nutrient concentrations were observed by the shoreline and near the DPCP outfall located within the NS monitoring area. In both wet and dry years, TP concentrations were below the IJC water quality objective for open waters at distances greater than 1 km from the shoreline. Significant differences in the median annual and median seasonal concentrations were observed for some nutrients which related to wet and dry years. *Keywords: Water quality, Nutrients, Lake Ontario.*

CHOWDHURY, M., WELLS, M.G., and COSSU, R., University of Toronto Scarborough, Toronto, ON, M1C 1A4. **Observations of the Contributions of Vertical Turbulent Mixing on the Dissolved Oxygen Budget in Lake Simcoe.**

We discuss potential contributions of turbulent transport of dissolved oxygen (DO) from the epilimnion to the hypolimnion to the DO budget in Lake Simcoe during strong summer stratification. We quantify the vertical mixing rates from a field study using an Acoustic Doppler Current Profiler to acquire high sampling frequency records of water velocities, which were processed to quantify the vertical eddy diffusivity, $K_z$. Internal turbulent mixing exhibited episodic behavior that correlated with the wind speed. The mean value of the turbulent mixing at the thermocline was $K_z \sim 10^{-6}\ m^2\ s^{-1}$, an order of magnitude higher than the molecular value. However, for the 10% of our observational period with persisting strong wind events (wind speed > 5 m $s^{-1}$), $K_z$ was close to $10^{-5}\ m^2\ s^{-1}$. Using measured DO values (from the Ministry of the Environment) and mean $K_z$ ($=10^{-6}\ m^2\ s^{-1}$) at the thermocline, we estimate that the turbulent DO flux for the August-September of 2011 was 0.15 g $m^{-3}$ $month^{-1}$ which is close to 10% of hypolimnetic oxygen demand (HOD). As wind speeds vary year-to-year, this may influence the apparent interannual variability in the HOD. *Keywords: Lake Simcoe, Oxygen, Water currents.*

CHRISTIE, G.C.[1], TAYLOR, W.D.[2], BAILEY, S.A.[1], and CUDMORE, R.C.[1], [1]Great Lakes Laboratory for Fisheries and Aquatic Sciences, 867 Lake Shore Rd., Burlington, ON, L7R 4A6; [2]University of Waterloo, 200 University Ave, W., Waterloo, ON, N2L 3G1. **Indicators of the Status of Aquatic Invasive Species in the Great Lakes.**

Efforts have been underway to define the most effective and efficient indicators of our progress toward the objectives of the newly revised Great Lakes Water Quality Agreement. Aquatic invasive species have harmed and are a continuing threat to the ecosystem health of the Great Lakes. Preventing new aquatic invasive species and reducing the harm of those that have established are commitments under the Great Lakes Water Quality Agreement. While the presence of new invaders can be simply represented, the summary of detection survey data and confirmation of establishment require care and completeness. The status and impact of established invasive species on a whole basin level is not simple. We consider the duration and extent of establishment and the scale of impact in selection of key species to represent overall status. *Keywords: Ecosystem health, Invasive species, Indicators.*

CIBOROWSKI, J.J.H.[1], KOVALENKO, K.E.[2], BRADY, V.[2], BROWN, T.[2], DANZ, N.[3], GATHMAN, J.[4], HOST, G.[2], HOWE, R.W.[5], AXLER, R.[2], NIEMI, G.J.[2], REAVIE, E.D.[2], and JOHNSON, L.B.[2], [1]University of Windsor, Department of Biology, Windsor, ON, N9B 3P4; [2]University of Minnesota Duluth, Natural Resources Research Institute, Duluth, MN, 55811; [3]University of Wisconsin Superior, Department of Biology, Superior, WI, 54880; [4]University of Wisconsin River Falls, Department of Biology, River Falls, WI, 54022; [5]University of Wisconsin - Green Bay, Department of Biology, Green Bay, WI, 54311.

**Comparing the Sensitivity and Consistency of Biological Indicators of Environmental Conditions: A Standard Protocol.**

We describe a common framework to assess effectiveness and consistency with which biological indices can classify sites varying in environmental condition (stress). Effective indices distinguish locations that support a biological community considered to be 'acceptable' vs. those that are 'unacceptable' and in need of remediation. Currently, 'equivalent to reference' is the measure of whether or not site condition is acceptable. The Reference-Degraded Continuum approach defines the complementary 'degraded condition', representing a level of stress deemed unacceptable by best professional judgement or consensus. We propose that "Index Effectiveness" (IE) is the proportion of sites correctly classified as being Nonreference (scores not meeting the operationally defined reference/nonreference criterion) plus the proportion correctly classified as Nondegraded (scores exceeding the operationally defined nondegraded/degraded criterion). We calculated IE scores of data as originally presented by proponents of several biological indices with IE scores of those same indices calculated from independently collected (validation) data. IE scores of training sets of data were uniformly high (>80%). However, the indices' abilities to correctly classify sites based on independent data were often no better than random. *Keywords: Bioindicators, Coastal ecosystems, Indicators.*

CLARK, R.D.[1], BENCE, J.R.[1], TSEHAYE, I.[1], MADENJIAN, C.P.[2], WARNER, D.M.[2], RILEY, S.C.[2], and HE, J.X.[3], [1]Quantitative Fisheries Center, Department of Fisheries and Wildlife, Michigan State University, East Lansing, MI, 48824; [2]USGS, Great Lakes Science Center, Ann Arbor, MI, 48109; [3]Michigan Department of Natural Resources, Alpena Research Station, Alpena, MI. **Lake-wide Chinook Salmon Abundances in Lakes Michigan and Huron Correlate with Changes in Alewife Abundance and Between-Lake Migration Patterns.**

We estimated lake-wide Chinook salmon and alewife abundances in lakes Michigan (LM) and Huron (LH) from 1985 through 2012. In LH, alewife abundance declined from 1994-2003 and has been very low (near zero) since. In LM, alewife abundance increased through 2000, but has steadily decreased to the lowest level for the period of record (100 kt) in 2012. In the mid-1990s, Chinook abundances began increasing in LM and decreasing in LH. In LH, Chinook abundance declined following the decline in alewife and has been very low (< 1 kt) since. Evidence from mark-and-recapture of hatchery-reared fish tagged with coded-wire-tags suggests that part of the reason for the trends in Chinook abundances was that their migration rates from LH into LM increased over the period. The increase in Chi-

nook in LM cannot be explained by increases in recruitment, because estimates of recruitment generally declined from the mid-1990s to present. In 2012, managers of LM cut Chinook stocking by 50% to preserve the dwindling alewife population, and hence, the Chinook fishery it supports. *Keywords: Salmon, Fish populations, Alewife.*

COLE, K.M.[1], GALAROWICZ, T.L.[1], CLARAMUNT, R.M.[2], CHADDERTON, W.L.[3], HERBERT, M.E.[3], TUCKER, A.J.[3], and GROSS, J.A.[4], [1]Central Michigan University, 184 Brooks Hall, Mount Pleasant, MI, 48859; [2]DNR - Charlevoix Fisheries Research Station, 96 Grant Street, Charlevoix, MI, 49720; [3]The Nature Conservancy, 1400 E Angela Blvd, Unit #117, South Bend, IN, 46617; [4]Smith-Root, 14014 NE Salmon Creek Avenue, Vancouver, WA, 98686. **Spatial and temporal distributions of the invasive Round Goby (*Neogobius melanostomus*) and Rusty Crayfish (*Orconectes rusticus*) on critical spawning reefs.**

Round Goby (*Neogobius melanostomus*) and Rusty Crayfish (*Orconectes rusticus*) are invasive egg predators prevalent on spawning reefs in northern Lake Michigan. There are limited data regarding Round Goby and Rusty Crayfish distribution on rocky reefs, with few studies examining seasonal distribution and use of interstitial habitats. The goal of this study was to determine the changes in Round Goby and Rusty Crayfish seasonal distribution on spawning reefs in Grand Traverse and Little Traverse Bays, Lake Michigan. Specifically, the objectives were to (1) determine if and how Round Goby and Rusty Crayfish abundance varies temporally and by depth, and (2) quantify changes of interstitial distribution. Standard minnow traps, buried egg bags, and underwater drop cameras were used in 2012 and 2013 to monitor seasonal changes. Round Goby and Rusty Crayfish reached higher densities in mid October, with most densities peaking at shallow depths. Although densities decreased as temperatures declined, a portion of the Round Goby population remained on the reefs and moved deeper into the substrate. These findings will help fisheries managers better understand seasonal abundance shifts in order to develop effective management strategies targeting Round Goby, Rusty Crayfish and other invasive species in the Great Lakes. *Keywords: Lake Michigan, Distribution patterns, Round goby.*

CONCHA, J.A., Digital Imaging and Remote Sensing Lab, Rochester Institute of Technology, Rochester, NY, 14623. **Water Constituent Retrieval over Case 2 Water using Landsat 8: Initial Results.**

Landsat 8, recently launched (February 2013), with its improved spectral coverage and radiometric resolution, has the potential to dramatically improve our ability to simultaneously retrieve the three primary coloring agents (chlorophyll, colored dissolved organic matter (CDOM), and suspended matter) from water bodies, and considering its 30-meter resolution, it should be especially useful for studying the nearshore environment. In this work, a look-up-table (LUT) methodology is implemented to retrieve concentration of water constituents using Landsat 8 imagery. The in-water radiative transfer code HydroLight is utilized to create the LUT. A non-linear optimization routine that solves non-linear least-square problems is used to perform the retrieval. In the Case 2 water problem, accurate atmospheric correction is essential, yet remains a significant source of water-constituent retrieval error. To atmospherically correct the image, a modified version of the empirical line method (ELM) has been developed, which utilizes reflectance from both HydroLight and a reflectance product to atmospherically correct Landsat 8 images. Early results of this methodology are shown in this work. *Keywords: Lake Ontario, Water quality, Monitoring.*

CONFESOR, R.B., NCWQR, Heidelberg University, 310 E Market St, Tiffin, OH, 44883.
**Modeling the Impacts of Best Management Practices (BMP) Adoption at the Watershed Scale.**

There is a notion that individual farmlands are relatively small compared to the whole watershed area to have substantial effect on its water quality. This belief is used to rationalize the reluctance in the adoption of conservation practices aimed to improve the water quality of the watershed. This presentation focuses on the adoption of best management practices (BMPs) across watersheds and its cumulative effect on water quality at the watershed outlet. The project area includes the Sandusky watershed and its sub-watersheds (Honey Creek and Rock Creek) in northwest Ohio. The Soil and Water Assessment Tool (SWAT) model was used in this modeling exercise to evaluate the effects of BMPs, specifically no-tillage and subsurface fertilizer application, on nutrients (phosphorus, P and nitrogen, N) and sediment export from the watershed. These BMPs were evaluated at 25%, 50%, and 100% adoption across the whole watershed. The effects of BMP adoption at the headwaters, near the watershed outlet, and randomly across watershed were also explored *Keywords: Phosphorus, Best Management Practices, Conservation, Tillage, Watersheds, Fertilizer.*

CONROY, J.D.[1], KANE, D.D.[2], BRILAND, R.D.[3], and CULVER, D.A.[4], [1]Ohio Department of Natural Resources, Division of Wildlife, Inland Fisheries Research Unit,10517 Canal

Road SE, Hebron, OH, 43025; [2]Defiance College, Division of Natural, Applied, and Social Sciences, Defiance, OH, 43512; [3]The Ohio State University, Department of Evolution, Ecology, and Organismal Biology, Columbus, OH, 43210; [4]The Ohio State University, Department of Evolution, Ecology, and Organismal Biology, Columbus, OH, 43210. ***Microcystis*** **blooms and phosphorus dynamics in two of Lake Erie's agricultural tributaries (Maumee and Sandusky rivers).**

Recurrent, massive cyanobacterial blooms composed mainly of the genus *Microcystis* indicate a broad-scale re-eutrophication of Lake Erie. In the past, ameliorating eutrophication relied on intentionally decreasing tributary nutrient, especially phosphorus, loads to the lake. However, recent research has shown that tributaries load not only nutrients but also bloom-levels of phytoplankton, including *Microcystis*. We built on this previous work by sampling earlier in the year and in much smaller tributaries in both the Maumee and Sandusky systems. We measured phosphorus, chlorophyll *a*, phycocyanin, and *Microcystis* biomass during March- October 2009 and 2010 in the Maumee and Sandusky rivers and selected tributaries to these highly agricultural rivers. We found *Microcystis* wet biomasses in these tributaries to be high and similar in both years. Importantly, we found *Microcystis* in small ditches in March, much earlier than previously had been found. *Microcystis* biomass in the lake did not correspond to measured phosphorus, chlorophyll *a*, or phycocyanin concentrations. These findings emphasize that the problem of *Microcystis* blooms really starts upstream much earlier in the year than just offshore in Lake Erie in late summer. *Keywords: Phosphorus, Rivers, Microcystis, Watershed, Lake Erie.*

CORCORAN, P.L., ZBYSZEWSKI, M., and HOCKIN, A., University of Western Ontario, 1151 Richmond St. N, London, ON, N6A 5B7. **Distribution and Degradation of Plastic Debris along the Shorelines of the Great Lakes, North America.**

The distribution, composition, and textures of plastic debris along the Lake Erie, Huron and St. Clair shorelines were studied to determine the roles of input sources, surface currents, and shoreline types in plastics accumulation. Abundant plastic pellets were found along the southeastern shore of Lake Huron, whereas the Lake Erie and St. Clair shorelines mainly contained plastic fragments and intact products. Potential sources for pellets could include spillage within factories, or during transport or off-loading, whereas intact products represent urban waste. The plastics analyzed were mainly composed of polyethylene and polypropylene, which were weathered at either the water surface or on the shoreline. Intact products were broken down by waves or sand abrasion into mm-cm size particles. Surface textures on plastics could be related to the type of depositional environment. Plastics sam-

pled from muddy, organic-rich shorelines had less mechanical pits than those from sandy beaches. The Lake St. Clair shoreline contained the least amount of plastic debris overall. This may be due to the breakwaters and retaining walls along Lake St. Clair, which replace natural sandy or muddy sinks for floating polymers. This study represents the first detailed record of plastics distribution along multiple, but related fresh water shorelines. *Keywords: Microplastics, Lake Huron, Deposition, Lake Erie, Lake St. Clair.*

COTNER, J.B.[1], CORY, R.M.[2], AMADO, A.M.[3], JACOBSON, M.F.[1], and MCNEILL, K.P.[4], [1]100 Ecology/1987 Upper Buford Circle, Dept. Ecology, Evolution and Behavi, Saint Paul, MN, 55108, United States; [2]2534 CC Little Bldg, Earth and Environmental Sciences Department, Ann Arbor, MI, 48109; [3]Universidade Federal do Rio Grande do Norte, Department of Oceanography and Limnology, Natal, RN, 59017, Brazil; [4]Swiss Federal Institute of Technology, Institute of Biogeochemistry and Pollutant Dynamics, Zurich, 8092, Switzerland. **Fluorescent dissolved organic matter and nearshore to offshore gradients in Earth's largest lake.**

Lake Superior, an ultra-oligotrophic lake holding 10% of the world's surface freshwater, contains a large pool of organic carbon, most of which is dissolved (DOC; 1-2 mg C/L). While Lake Superior is already experiencing climate change impacts such as increasing temperatures and extended periods of summer stratification, there remain key uncertainties in the carbon and nitrogen cycles that center on the source and quality of dissolved organic matter (DOM) in Lake Superior. We employed fluorescence spectroscopy to determine the sources and processes responsible for transformations of fraction of DOM in Lake Superior and one its major tributaries by collecting samples throughout the water column on eight cruises spanning May through October, 2006-2008. Parallel factor analysis (PARAFAC) of the fluorescent fraction of DOM (FDOM) revealed six unique components originating from terrestrial, autochthonous, and/or proteinacous precursor material. The pattern revealed from the temporal and spatial trends in riverine and Lake Superior FDOM was of a strong removal of terrestrially-derived humic DOM with increasing importance and variability in DOM associated with autochthonous sources along the riverine to offshore transect. We also observed the production and removal of autochthonous FDOM in spring. *Keywords: Biogeochemistry, Phosphorus, Coastal processes, Nitrogen, Dissolved organic matter.*

CRIBLEY, J. and LEONARD, J.B.K., Biology Department, Northern Michigan University, Marquette, MI, 49855. **Habitat selection by longnose dace (*Rhinichthhys cataractae*) in an artificial stream setting.**

With our increasing appreciation of the importance of aquatic community complexity, it is obvious that studying understudied fish community members is important for understanding ecosystem functioning. Longnose dace (*Rhinichthys cataractae*) are riffle-dwelling, coldwater stream fish native to southern Canada and northern U.S. Individuals are usually found in fast-flowing riffles with rocky substrate. They have been shown to avoid slow current and abundant sand, silt, and debris. Although we know the general habitat these fish tend to select, specific characteristics driving these choices are unclear. Dace (N=26) were implanted with 23mm RFID PIT tags and placed in an artificial stream where movements among pools and riffles as well as high and low velocity areas were monitored under varying photoperiod and temperature conditions. Activity of dace was greatest during dawn/dusk as well as evening hours with little daytime activity, regardless of photoperiod regime; fish were more active at 15ºC than 5ºC. When given the opportunity, fish were more common in fast flowing riffles with rocky substrate; however, rocky substrate was more highly selected than water velocity. Our data highlight the diurnal/nocturnal behavior patterns of this species and highlight its preference for substrate over velocity. *Keywords: Fish behavior, Native fish species, Tributaries.*

CRIMMINS, B.S., XIA, X., HOPKE, P.K., and HOLSEN, T.M., Clarkson University, Potsdam, NY. **Shotgun Screening of Great Lakes Lake Trout using Atmospheric Pressure Gas Chromatography - Quadrupole Time of Flight Mass Spectrometry.**

The Great Lakes Fish Monitoring and Surveillance Program is currently developing a spectral database for the discovery of emerging chemicals in lake trout. One of the tools currently employed in the Atmospheric Pressure Gas Chromatograph (APGC) equipped with a Quadrupole Time of Flight (QToF) Mass Spectrometer. The mass spectrometer is currently configured to collect, paired, high and low energy spectra during each cycle. The atmospheric pressure ionization allows for direct charge transfer and proton transfer ionization depending on whether a dopant is used. Enhanced sensitivities were observed for polar compounds with the addition of a water dopant. The addition of select dopants such as water, methanol and acetone, may provide selective sensitivity enhancements of non-targeted emerging species providing a more robust spectral database for future cataloging. The current paper explores the utility of using the APGC-QToF and different ionization modifiers for non-directed exploration of lake trout composites for emerging chemicals. *Keywords: Environmental contaminants, Mass spectrometry, Lake trout.*

CROSSMAN, J.H.[1], STAINSBY, E.[2], ONI, S.K.[3], FUTTER, M.N.[3], and DILLON, P.J.[1], [1]Chemistry Department, Trent University, Peterborough, ON; [2]Environmental Monitoring & Reporting Branch, Ontario Ministry of the Environment, Toronto, ON; [3]Department of Aquatic Science and Assessment, Swedish University of Agricultural Science, Uppsala, Sweden. **The Impact of Uncertainty in Climate Change on Projections of Water Quality in Lake Simcoe.**

Using a Perturbed Physics Ensemble (PPE) we assess uncertainties in future projections of precipitation and temperature, and their potential consequences for water quality projections in six Lake Simcoe sub-catchments. Comparisons between ensemble members showed increases in climatic uncertainty between 2030 and 2070; though differences between catchments are small (< 9%). Effects of uncertainty on hydrologically effective rainfall (HER), discharge and water quality depended on catchment characteristics. PPE-related uncertainty had the greatest impact on total phosphorus (TP) projections in catchments with high runoff rates and low soil water residence times, where TP is rapidly transported to the stream via surface and macropore flow. TP uncertainty can exceed 26.48%, and projected HER reductions can lead to considerable reductions in TP (>14%). Impacts are lower in catchments where long soil-water residence times and low runoff coefficients direct a greater proportion of water through the soil matrix. Here, small changes in TP were projected, with uncertainty as low as 9.07%. These findings have significant implications for the management of Lake Simcoe and other large inland lakes, where tailoring of management strategies to individual catchment characteristics is required. *Keywords: Climatic data, Water quality, Lake Simcoe.*

CROUCHER, K.N. and EIMERS, M.C., Trent University, 1600 West Bank Drive, Peterborough, ON, K9J 7B8. **De-icing Salt Accumulation in Roadside Soils - Possible Linkages with Groundwater Quality in Southern Ontario.**

Sodium ($Na^+$) and chloride concentrations are rising in populated watersheds across southern Ontario as a result of road salt runoff from impervious surfaces. Sodium retention in roadside soils can 'protect' surface and groundwaters, although the potential for $Na^+$ retention in soil is likely to vary depending on the extent of base saturation on the cation exchange complex. This is of particular relevance in the most populated region of southern

Ontario, where soil parent material varies greatly from base-poor Canadian Shield material in the north, to glacially-reworked and calcium ($Ca^{2+}$) enriched parent material in the south. This study contrasted $Na^{+}$ retention in roadside soils spanning different parent materials within Southern Ontario, and examined the physical effects of $Na^{+}$ accumulation in soil. Preliminary data show that roadside soils have higher pH and lower hydraulic conductivity and organic matter content, and physical degradation was more substantial in low $Ca^{2+}$, Shield-derived soils. Reduced $Na^{+}$ retention in $Ca^{2+}$-rich soils suggests that $Na^{+}$ transfer to groundwater will be greater in calcareous parent material. Batch experiments will be used to identify the mechanisms of $Na^{+}$ retention and leaching. *Keywords: Urban watersheds, Sodium retention, De-icing salt, Soil.*

CRUZ-FONT, L.[1], VEILLEUX, M.A.N.[1], HLEVCA, B.[2], MIDWOOD, J.D.[1], WELLS, M.G.[2], COOKE, S.J.[1], and DOKA, S.E.[3], [1]Carleton University, Ottawa, ON; [2]University of Toronto Scarborough, Toronto, ON; [3]Department of Fisheries and Oceans, Great Lakes Laboratory for Fisheries & Aquatic Sciences, Burlington, ON. **Fish movements in Toronto Harbour associated with upwelling events.**

Fish habitat selection and movements are influenced by a suite of environmental variables. Water temperature is one of the most studied due to the intrinsic effect of this variable on the biological processes of organisms. Littoral fish are particularly influenced by fluctuations in water temperatures, mainly during the summer where this process is more common. The Toronto Harbour exhibits such temperature fluctuations, or upwellings, with changes of around 10 - 16ºC in relatively short time periods. This type of event can occur several times during the summer, and with different intensities, such that the effects can be spread to relatively protected areas of the inner harbour. Fish that inhabit these areas of the lake have to cope with the rapid changes in temperature; therefore their movements should be influenced by the irregular environmental process. This study explores fish movements in the Toronto Harbour during three upwelling events of 2012. Fish were tagged with acoustic transmitters, released and tracked with an array of receivers that covered the area of the Harbour. Water temperatures were recorded throughout the duration of the study. This research will help understand the habitat selection for resident and non-resident fish during environmental disturbances such as the upwelling events. *Keywords: Bottom currents, Fish tagging, Fish behavior, Habitat selection, Lake Ontario, Temperature fluctuations.*

CUMMINGS, T.F., SCHIFF, S.L., SPOELSTRA, J., and ELGOOD, R.J., Dept. Earth & Environmental Sciences, University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L 3G1. **Nitrate Export and Source Determination in Small Agricultural Catchments.**

Nitrate ($NO_3^-$) is one of the most widespread contaminants in freshwater systems. Elevated concentrations can cause detrimental health effects to both humans and aquatic ecosystems. Small agricultural catchments play an important role in nutrient export to larger freshwater systems. However, large changes in nutrient concentration can occur over the course of a year. Four small agricultural catchments with >77% agricultural land use were selected for study. These catchments are located within the Grand River Watershed and have drainage areas ranging from 44 to 88 $km^2$. Nitrate concentrations in these small catchments varied seasonally concomitantly with stream discharge so that increased concentrations and export both occurred during the non-growing season. Peak export and concentrations (>10mgN/l) were observed during early winter melt events and lowest concentrations (<5mgN/l) and export occurred during the summer months. Stable isotope analysis of $\delta^{15}N$ will be used to examine seasonal changes in processes controlling N cycling. *Keywords: Nutrients, Agriculture, Isotope studies, Predation.*

CURRIE, W.J.S., LINLEY, R.D., GERLOFSMA, J., KOOPS, M.A., and BAILEY, S.A., Great Lakes Laboratory for Fisheries and Aquatic Sciences, 867 Lakeshore Rd., Burlington, ON, L7R 4A6. **Sampling the Western Lake Ontario Basin Ecosystem Using New and Old Tools.**

For the 2013 Lake Ontario CSMI year, DFO undertook a 50 km cross-lake transect of the Western Ontario Basin (WOB) from Port Dalhousie to Humber Bay during spring, summer and fall. Six stations (at 15, 60, 100m depths north and south) were sampled for nutrients, light attenuation, phytoplankton taxonomy and primary production, microbial food web, zooplankton, Mysids and a Fluoroprobe profile. Forage fish were sampled using midwater trawls, vertical gill nets and fish-hydroacoustics. In addition, a Laser Optical Plankton Counter (LOPC) was used to count and size particles in the water column >80 µm. Day and night continuous tow-yo transects of the top 30m and profiles of the whole water column were sampled using the SHRIMP array, consisting of the LOPC/CTD and YSI EXO2 sonde on an Acrobat towbody with active depth regulation. This type of towed array is not commonly used in freshwater but is highly suited to coastal environments, and due to its small size, can be deployed and operated from small vessels in shallow to deep water environments. We will outline the data collected during this project, using standardized methods across the lake, discuss the nearshore-offshore differences and illustrate the integration of new equipment that permits rapid assessment of the physical and biological components of the pelagic ecosystem. *Keywords: Lake Ontario, LOPC, Spatial distribution, Transect, Food chains, CSMI.*

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DAMMERMAN, K.J.[1], STEIBEL, J.P.[2], and SCRIBNER, K.T.[2], [1]Dept. of Zoology, Michigan State University, 288 Farm Ln, Rm 203, Nat Sci, East Lansing, MI, 48824; [2]Dept. of Fisheries & Wildlife, Michigan State University, 480 Wilson Rd, Rm 13, Nat Res Bldg, East Lansing, MI, 48824. **The effects of thermal incubation regimes on larval lake sturgeon development and behavior.**

Climate change and variability is affecting thermal regimes worldwide. Understanding how variation in temperature affects species development is a major goal for Great Lakes researchers and managers. Aquatic ectotherms are particularly susceptible to environmental variability given that Great Lakes tributaries are important integrators of climatic features. Using lake sturgeon (*Acipenser fulvescens*) from Black Lake, MI, we reared eggs from ten half-sib families under four thermal regimes: two constant (10 and 18C) and two fluctuating (10-19C) treatments representing mean, ambient, and the highly variable effects of dam impoundment on diel variation in water temperature. Individuals were photographed at hatch to quantify phenotypic traits, placed in incubation chambers, and monitored until emergence. Repeated measures of phenotypic traits at emergence were used to estimate growth. Larval traits at hatch significantly varied between families due to genotype-by-environment interactions. The largest range of phenotypic variation was observed in the constant 18C treatment. Family (additive variance) and treatment effects were also associated with emergence time and growth. Results indicate that thermal conditions experienced during early ontogenetic stages can alter the phenotypic and genotypic distribution of the population. *Keywords: Climate change, Fish, Management.*

DANIEL, S.E., BURLAKOVA, L.E., KARATAYEV, A.Y., TULUMELLO, B.L., FISHER, J., HASTINGS, K.L., and PAWLOWSKI, K.J., Great Lakes Center, SUNY Buffalo State, 1300 Elmwood Avenue, Buffalo, NY, 14222. **Long-Term Benthic Monitoring of Laurentian Great Lakes.**

Great Lakes Center in collaboration with Cornell University are participating in a long-term biological monitoring across all Laurentian Great Lakes. During this project we collected benthos (Buffalo State), zooplankton, and chlorophyll data (Cornell University) across the five lakes in 2013 and will collect annually until 2017 onboard of EPA *R/V Lake Guardian*. The information obtained will be added to EPA's Long-Term Monitoring data and will be used to find long-term trends in benthic community structure and to evaluate biotic indices of ecosystem health. We will apply and compare the existing benthic indices and other promising bioindicator systems, and develop new multivariate biological indexes based on both benthic density and biomass for various types of habitats in the Great Lakes. Currently we are identifying benthic samples collected in 2012, and 2013. We will present data on species composition, density, and biomass for 2012 benthic survey. *Keywords: Great Lakes basin, Benthos, Monitoring, Bioindicators.*

DAVID, S.R.[1], HANSEN, S.P.[2], MCINTYRE, P.B.[3], and MADENJIAN, C.P.[4], [1]Shedd Aquarium, 1200 South Lake Shore Drive, Chicago, IL, 60605; [2]Wisconsin Department of Natural Resources, 110 S Neenah Avenue, Sturgeon Bay, WI, 54235; [3]University of Wisconsin, 680 North Park St., Madison, WI, 53706; [4]USGS Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105. **Using stable isotopes to investigate reemergence of riverine Lake Whitefish *Coregonus clupeaformis* migrations in northern Lake Michigan.**

The Lake Whitefish (*Coregonus clupeaformis*) constitutes the largest commercial fishery in Lake Michigan, and is an economically and ecologically important species throughout the Great Lakes. River spawning migrations of Lake Whitefish greatly declined in the early 20th century, but have reemerged in the past decade. The primary drivers for reemergence of Lake Whitefish migrations in northern Lake Michigan (specifically Green Bay tributaries) are currently unknown; additionally, little is known regarding the ecology of these river-spawning populations. We compared stable isotope signatures (δ15N, δ13C) of multiple river- and nearshore-spawning Lake Whitefish populations in northern Lake Michigan to identify potential differences among migratory and non-migratory populations. Results indicated river-spawning Lake Whitefish were significantly different in stable isotope signatures from nearshore-spawning Lake Whitefish in northern Lake Michigan. These results will help identify migratory and non-migratory Lake Whitefish populations during non-spawning season sampling, therefore informing management and further study of the drivers of these new migrations. *Keywords: Fish populations, Life history, Isotope studies, Lake whitefish, Migrations.*

DAVIS, T.W.[1], WATSON, S.B.[1], ROZMARYNOWYCZ, M.J.[2], BULLERJAHN, G.S.[2], CIBOROWSKI, J.J.H.[3], and MCKAY, R.M.L.[2], [1]Canada Centre for Inland Waters, Environment Canada, Burlington, ON, L7R 4A6; [2]Department of Biological Sciences, Bowling Green State University, Bowling Green, OH, 43403; [3]Department of Biological Sciences, University of Windsor, Windsor, ON, N9B 3P4. **Molecular and taxonomic characterization of potential microcystin-producing cyanobacteria in Lake St. Clair during a late summer bloom.**

Cyanobacterial harmful algal blooms (CHAB) occur regularly in the lower Great Lakes (LGLs; Erie and Ontario) hence most of the Great Lakes CHAB research to date has focused on these two lakes. As such, Lake St. Clair (LSC) has been largely overlooked. This smaller, shallow lake receives water from Lake Huron and feeds into Lake Erie via the Detroit River. LSC also receives inflow from wastewater treatment plants and tributaries which drain a rich agricultural region. Despite anecdotal reports and satellite imagery showing blooms along the south and east coastlines during the summer, few studies have investigated the phytoplankton in LSC or their impacts downstream. Furthermore, no study has investigated their toxicity, taxonomic or molecular diversity and their relationship to CHAB events in the LGLs. Our study addressed this critical gap by: 1) tracking the development of the 2013 LSC summer south-east shore bloom, 2) sampling a spatial transect of the bloom for the dispersion, toxicity, taxonomic composition and the phylogenetic diversity of potential microcystin (MC)-producing cyanobacteria (*Microcystis, Planktothrix, Anabaena*); 3) comparing the strains of potential MC-producers in LSC and the LGLs, including the Areas of Concern: Hamilton Harbor and Bay of Quinte. Here we report the results of this work *Keywords: Harmful algal blooms, Microcystis, Lake St. Clair, Microcystin, Genetics.*

DEBERTIN, A.J. and NUDDS, T., Department of Integrative Biology, University of Guelph, Guelph, ON, N1G 2W1. **Why do non-quota commercial fisheries persist in Lake Erie?**

To be amended: Typically, commercial fisheries do not persist without extensive management methods such as quota systems which restrict the total allowable catch for a species. A quota was established for the Lake Erie gillnet fishery for yellow perch (*Perca flavescens*) whereas white perch (*Morone americana*) and white bass (*Morone chrysops*) are harvested without quota; yet these fisheries continue to persist. Bayesian surplus-production stock assessment models were performed, with and without informed prior distributions of parameters, to investigate the impact on the risk status for overfishing or being overfished. The current likelihood that overfishing occurred and that these stocks are in state of being overfished are low. However, fisheries exploitation rates were high during the 1990s and risk statuses associated to each stock were high during that period. Harvesters may have increased fisheries exploitation of white perch and white bass in the 1990s to compensate for lost wages due to a reduction in yellow perch quota. We suggest strong-weak interactions between a monetary-driven fishery and quota/non-quota fish species can provide a possible explanation to the persistence of multi-species commercial fisheries. *Keywords: Percids, Fisheries, Lake Erie.*

DELACH, D.L., CRIMMINS, B.S., and HOLSEN, T.M., Clarkson University, 8 Clarkson Ave, Box 5708, Potsdam, NY, 13699. **Fatty acid fractionation patterns and their correlation with stable isotopes and stomach content analysis in two lakes.**

The Great Lake Fish Monitoring and Surveillance Program (GLFMSP) screens fish for contaminants in an effort to track environmental trends and assess ecosystem health. Fatty acids can be used to trace the energy flow through an aquatic system. Fish collected for this program indicated statistically significant differences in fatty acids among prey and predator fish, as well as between Lakes Huron and Superior. Trout occupied the highest trophic levels in both lakes, though total fatty acid concentrations were higher in Lake Huron trout(450.59±221.43mg/5g fish) than in Lake Superior(144.84±72.29mg/5g fish). This trend was consistent for all fatty acids in trout. Kiyi(Coregonus kiyi) had fatty acid concentrations nearly four times higher than seen in other prey fish types. No differences in concentration or fractionation among sampling sites were detected. Fractionation patterns indicated some significant differences in polyunsaturated fatty acids (PUFAs) among prey fish. Kiyi were usually the driver behind these differences. Average PUFA content in kiyi is just 38% of total fatty acids; whereas in deepwater sculpin, PUFA make up 53% of total fatty acids. Stomach content and isotopic analysis have also been explored in conjunction with particular acids as indicators of foodweb linkages among particular species. *Keywords: Bioenergetics, Food chains, Fish diets.*

DELACH, D.L., CRIMMINS, B.S., and HOLSEN, T.M., Clarkson University, 8 Clarkson Ave, Potsdam, NY, 13699. **PFC concentrations and accumulation potential among predator and prey fish in the Great Lakes.**

Since their first reported presence in biota in 2001, perfloroalkyl compounds (PFCs) have been identified as bioaccumulative and found worldwide in environmental media. Though their sources are still being characterized, these compounds have been detected in many components of the Great Lake food webs. Predator and prey species were collected from Lake Superior in 2011 and from Lake Huron in 2012. PFCs were detected in all samples. Prey fish in both lakes typically have greater total PFC concentrations than those observed in predator fish, for example in Lake Huron smelt concentrations (22.49 ± 12.48 ng/g w.w.) far exceeded those of lake trout (16.51 ± 8.49). PFOS consistently had the highest concentration relative to other PFCs. In Lake Superior fish, PFOS concentrations were the greatest in deepwater sculpin (14.06 ± 11.40 ng/g w.w.). Total PFCs were detected in lake trout at concentrations as high as 46.17 ± 43.50 ng/g w.w. in Lake Superior. The presentation provides a detailed analysis of the food chain flow of PFC bioaccumulation and will be compared to dietary metrics such as stable isotopes of C and N, and fatty acid profiles. *Keywords: Perfluorooctane sulfonate, Trophic level, Food chains.*

DELLINGER, J.[1] and SERVEISS, V.[2], [1]Concordia University Wisconsin, 12800 N. Lake Shore Drive, Mequon, WI, 53097-2402; [2]IJC US Section, 1250-23rd Street, N.W. Suite 100, Washington, DC, 20330. **Developing Human Health Indicators for the IJC Using the Fish Consumption Indicator as an Example.**

The 2012 Great Lakes (GL) Water Quality Agreement (GLWQA) directs the USA and Canada to restore and maintain the chemical, physical, and biological integrity of the waters of the Laurentian GL. IJC Commissioners asked HPAB to work with the Science Advisory and Water Quality Boards, who were working on ecosystem indicators, to propose human health indicators to assess progress in meeting GLWQA goals. HPAB convened a workshop in Chicago with bi-national experts to create, evaluate and propose five human health indicators to the Canadian and U.S. governments. Indicators were proposed in three GLWQA categories: drinking water, recreational water contact, and fish consumption. The development of the fish consumption indicator is described here to illustrate the HPAB process, with the remaining categories covered by separate presentations. "Contaminant levels in GL edible fish" is proposed as an exposure indicator of reducing health risks from human consumption of five commonly consumed fish commonly caught by commercial and sport-fishers: lake trout, walleye, smallmouth bass, yellow perch and whitefish. Whitefish and lake trout are commercially harvested by tribes in the upper GL treaty territories. HPAB is also exploring the governments' fish consumption advisory restrictions severity rating as a management response indicator. *Keywords: Indicators, Human health, Fish.*

DEMARCHI, C.[1], SU, Y.[1], and HE, C.[2], [1]Department of Earth, Environmental, and Planetary Sciences, Case Western Reserve University, Cleveland, OH, 44106-7216; [2]Department of Geography, Western Michigan University, Kalamazoo, MI, 49008-5424. **Assessing the Impact of Urbanization on the Hydrology of the Chagrin River, a Suburban Watershed Near Cleveland (Ohio), and Exploring Possible Remediation Strategies.**

The Chagrin River watershed is a middle size basin located in the eastern fringe of the Cleveland metropolitan area. Once a rural and forested area so pristine to be designated as a Scenic River by the State of Ohio, this watershed has been experiencing a rapid urbanization. The consequent increase in the area covered by impervious surfaces and changes in precipitation patterns have contributed to a dramatic increase in flooding events in the downstream parts of the watershed and in river erosion in the upper and middle parts. We have developed a model of this watershed using a new version of the Distributed Large Basin Runoff Model, calibrated it for the period 1991-2000 and validated it for the period 2003-2012, taking into consideration land use changes as reported by the Coastal Change Analysis Program. Then, we have explored the effects of possible land use changes on the hydrology of the watershed. Finally, taking advantage of the work on stormwater Best Management Practice carried out by the Chagrin River Watershed Partners- National Estuarine Research Reserves System Science Collaborative Project, we have evaluated the results of some remediation strategies. *Keywords: Flooding, Land use changes, Watershed hydrology.*

DEPINTO, J.V.[1], VERHAMME, E.M.[1], RICHARDS, R.P.[2], KREISS, R.G.[3], and DOLAN, D.M.[4], [1]LimnoTech, 501 Avis Drive, Ann Arbor, MI, 48108; [2]National Center for Water Quality Research, Heidelberg University, Tiffin, OH, 48883; [3]EPA Large Lakes Research Station, 9311 Groh Road, Grosse Ile, MI, 48138; [4]University of Wisconsin-Green Bay, Green Bay, WI. **Trends in Phosphorus Loading to the Western Basin of Lake Erie.**

Dave Dolan spent much of his career computing and compiling phosphorus loads to the Great Lakes. None of his work in this area has been more valuable than his continued load estimates to Lake Erie, which has allowed us to unambiguously interpret the cyanobacteria blooms and hypoxia development in the lake. To help understand the re-occurrence of cyanobacteria blooms in the Western Basin of Lake Erie, we have examined the phosphorus loading to the Western Basin over the past 15 years. Furthermore, we have examined the relative contributions from various tributaries and the Detroit River. On an annual basis the total phosphorus load has not exhibited a trend, other than being well correlated with flow from major tributaries. However, the dissolved reactive phosphorus (DRP) load has trended upward, returning to levels observed in the mid-1970s. This increase has largely been attributed to the increase in flow-weighted DRP concentration in the Maumee River. Over the period, about half of the phosphorus load comes from the Maumee River with the other half coming from the Detroit River; other tributaries contribute much smaller amounts to the load. Seasonal analysis shows the importance of spring (March-June) high flow events. We are very grateful to our friend Dave for making this type of analysis possible *Keywords: Phosphorus, Lake Erie.*

DESJARDINS, P.S., Alpha Heart Wildlife, 393 Margueretta Toronto Ontario, Toronto, ON, M6H 3S6. **Alpha Heart Wildlife Presents: The Kawartha Turtle Trauma Center.**

Seven out of eight species of turtle in Ontario are now threatened or at risk. In this session you will be viewing a documentary produced by Pierre Desjardins, founder of "Alpha Heart Wildlife" an independent advocacy project for wildlife conservation. This documentary provides a brief summary of the conservation efforts of the Kawartha Turtle Trauma Center: a one-of-a-kind turtle rehabilitation center located in Peterborough, Ontario. It explains the process of rehabilitating injured turtles as well as the initiatives carried out by the KTTC to collect biological data from these at-risk reptiles. Road fatalities are one of the biggest threats facing the ecology and biodiversity of turtles in Ontario. As such, care is taken in raising viewer awareness of the need to contribute to the safety of turtles on roads and highways, especially near shores and bodies of water. Other key aspects of the KTTC's mandate is presented, including their vibrant outreach programs to create awareness for turtle conservation as well as their "head starting" turtle nursery program. Viewers will leave inspired by the documentary shouldering a better appreciation of the need to share responsibility for our natural environment. *Keywords: Reptiles.*

DICKINSON, W.T.[1], RUDRA, R.[1], KOZYN, A.[1], and AMILI, A.[2], [1]School of Engineering, University of Guelph, Guelph, ON, N1G 2W1; [2]Golder Engineering, Toronto, ON. **Impacts of Climate Change on Winter Hydrology and Sediment and Nutrient Transport.**

Time series of temperature and precipitation for selected climate stations across Ontario were explored using Mann Kendall and Linear Regression trend analyses. All temperatures except extreme daily maxima have increased steadily for periods of record from 70 to 165 years, winter temperatures having increased the most. The frequency distributions of winter daily minimum temperatures revealed that not only did the mean winter daily minima shift in the positive direction by about 2 Celsius degrees per 100 years, but also the standard deviations of these distributions decreased nonlinearly. A net result of such shifts has been a near exponential increase in the number of frost-free days per winter, that increase being almost 1 month in the last 100 years in Southern Ontario. Winter precipitation records revealed that winter rainfall has increased at all selected stations and winter snowfall has decreased at most stations. Likely impacts of these changes include: an increase in the number and volume of winter snowmelt events, and of winter runoff and/or winter groundwater and tile flow events; and a decrease in the end-of-winter snowpack, with an associated decrease in the volume and peak discharge of spring snowmelt floods. Changes in the frequency, magnitude and timing of sediment and nutrient loads can also be expected. *Keywords: Hydrologic cycle, Sediments, Climate change, Nutrients.*

DIJKSTRA, M.L.[1], AUER, M.T.[2], GAWDE, R.K.[1], and AUER, N.A.[2], [1]Department of Civil & Environmental Engineering, Michigan Technological University, 1400 Townsend Drive, Houghton, MI, 49931; [2]Great Lakes Research Center, Michigan Technological University, 1400 Townsend Drive, Houghton, MI, 49931. **Ecosystem Function in Lake Superior: Impacts of an Episodic Climate Anomaly.**

Climate change may become manifest over differing time scales: one characterized by long term, incremental changes as recorded in historical averages and the other by short term variability, e.g. the magnitude, timing, frequency and duration of episodic, extreme events. The ecological impact of extreme weather events may be particularly severe, simply because they are extreme, but also because ecosystems have rarely been exposed to such events. Due to the inherent unpredictability of extreme events, few studies have reported on the attendant ecosystem response. Here, the effects of an episodic air-temperature anomaly that occurred in Spring 2012 are reported and compared to those of 2011, a year with essentially average temperature conditions. Impact of this extreme weather event on the lake's thermal regime and ecological forcing conditions (e.g. light, temperature and nutrients) cascaded through the system. This resulted in elevated annual primary production with a distinctive temporal distribution characterized by high productivity in early summer followed by a collapse in September (brought on by nutrient depletion resulting from extended thermal stratification). The benefits of increased annual primary production to the higher food web may be offset by cataclysmic drops in production. *Keywords: Lake Superior, Primary production, Climate change, Productivity.*

DITTMAN, D.E., USGS, Tunison Laboratory of Aquatic Science, 3075 Gracie Road, Cortland, NY, 13045-9357. **Lake Sturgeon Status Metrics in the Oswegatchie and Oswego River Systems, New York, USA.**

Two of the river systems targeted for Lake Sturgeon restoration in New York are the Oswego and Oswegatchie watersheds, in which sturgeon had become rare and virtually undetectable. Fall fingerlings were released, 1994-2004, as part of the restoration effort. The Oswegatchie System (including Black Lake) received 20,000 Lake Sturgeon and the Oswego System 12,000. Three key metrics considered essential for Lake Sturgeon status assessment are spatial distribution, abundance, and size distributions. Research sampling efforts from 2005 to 2013 found Lake Sturgeon to be widespread among all assessed sections of the Oswegatchie and Oswego River Systems. Outside of very rare 0 sturgeon catch nights, catch per unit effort (CPUE) ranged from 0.11 to 9 sturgeon/net/night. The highest average CPUE's (4.0-6.7) were observed at probable spawning sites. In 2013, the average size of Lake Sturgeon in the Oswegatchie River was 1.0m and 7.8kg (n=30) and in Black Lake was 1.3m and 16.8kg (n=31). In the Oswego system the average size of Lake Sturgeon from the Seneca River was 1.2m and 8.4kg (N=26) and from Fish Creek was 1.4m and 22kg (N=29). These three metrics provide a positive measure of the progress of the restoration of this important native fish in these watersheds. *Keywords: Fish management, Sturgeon, Populations, Restoration metrics, Distribution patterns.*

DOBIESZ, N.E.[1], BENCE, J.R.[1], and HE, J.X.[2], [1]Michigan State University, 293 Farm Lane, Room 153, East Lansing, MI, 48824; [2]Michigan Department of Natural Resources, 160 East Fletcher Street, Alpena, MI, 49707. **Improving Our Understanding of Round Goby *Neogobius melanostomus* Population Dynamics in Lake Huron Using Estimates of Consumption by the Top Piscivores.**

Beginning in the 1990s, the prey fish community in Lake Huron experienced dramatic shifts in species composition with concomitant changes to predator consumption. In 1994, the non-native, bottom-dwelling round goby was found in Lake Huron and subsequently underwent broad range expansion. Then, between 1999 and 2004, alewife abundance and biomass declined by 99%. Diet studies showed that lake trout and walleye increased consumption of rainbow smelt and replaced alewife consumption with gobies after 2002. The changing benthic community resulted in an increase in piscivory by lake whitefish, with gobies becoming 35% or more of their diet after 2007. We recently estimated consumption by the major predators in the main basin of Lake Huron using linked stock assessment and biogenetics models. During 2003-2010, estimated annual predation pressure on goby was 3.7 kt but bottom trawl surveys suggested that goby biomass was not large enough to support this consumption. These conflicting results point to the need to further evaluate the population dynamics of round goby in Lake Huron. To this end, we employed a simplified catch-at-age model with estimates of predation pressure to evaluate population dynamics of round goby. *Keywords: Round goby, Lake Huron, Food chains.*

DOKA, S.E., MCNIECE, D.W., and GERTZEN, E.L., Fisheries and Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R4A6. **Challenges for GIS in Areas of Concern.**

Using GIS in Fish Habitat Modeling poses unique challenges for each Area of Concern in Ontario. What data there is available comes from a variety of sources at different time frames using different instrumentation measured and projected with different techniques and datums all with different purposes in mind. 'Cobblestoning' this picture together posed many interesting challenges ranging from geoprocessing tools to politics and data sharing agreements. While methods such as ground truthing could be used to verify some findings, other models were constructed using best available data and most likely theoretical scenarios. During a time of great change with flora, fauna and weather, change over time analysis becomes even more difficult. Constructing biotic indices to reflect the past has pitfalls but may be necessary as a starting point. What makes an Area of Concern what it is always creates restrictions on recommendations. Seawalls and riprap prevent restoration of riparian or littoral zones. Even if funding was available, some of these structures prevent erosion or serve purposes that cannot now be replaced. *Keywords: Model studies, Habitats, GIS.*

DOKA, S.E., GERTZEN, E.L., OUELLET, V., and ABDEL-FATTAH, S.L., Fisheries and Oceans Canada, Box 5050, 867 Lakeshore Rd., Burlington, ON, L7R 4A6. **Lake Ontario Nearshore Vulnerability Assessment.**

Current and future state comparisons of nearshore zone fish habitats and habitat-based projections of select fisheries in Lake Ontario under base case and 2041-2070 climate scenarios and gaming. *Keywords: Climate change, Nearshore zone, Lake Ontario.*

DOLL, J.D. and LAUER, T.E., Department of Biology, Ball State University, Muncie, IN, 47306. **Comparing Bayesian and frequentist methods of fisheries models: Hierarchical catch curves.**

Bayesian inference is an emerging statistical paradigm and is becoming an increasing used alternative to frequentist inference. Unfortunately, little is known about the efficacy of Bayesian inference and how it relates to the historical methodology of evaluating fisheries related models. The objective of this study was to compare frequentist and Bayesian inference approaches to estimate instantaneous mortality (Z) from a hierarchical catch curve model. The data used in the comparison were from a long term monitoring program of Yellow Perch from southern Lake Michigan in addition to a simulated dataset where parameter estimates were compared to known values. Point estimates of Z were similar among both methods. However, Bayesian inference 95% credible intervals were smaller than frequentist 95% confidence intervals, suggesting increased precision in the parameter estimates. Additionally, the root mean squared error of frequentist inference increased at a higher rate than Bayesian inference with increasing variability in the simulated dataset. Our study builds on the literature that seeks to compare results between these two paradigms to assist managers to make the best decision possible when deciding what statistical paradigm to employ. *Keywords: Yellow perch, Model testing, Computer models.*

DOLSON, R., ADKINSON, A., and LA ROSE, J., Southern Biodiversity and Monitoring Unit, Ontario Ministry of Natural Resources, 26465 York Rd. 18, Sutton West, ON, L0E1R0. **Characteristics of Recovering Lake Whitefish and Cisco Populations in Lake Simcoe.**

Lake Simcoe once sustained large populations of two commercially and recreationally important fish species, Lake Whitefish and Cisco (Salmonidae: Coregoninae). Their populations collapsed in the 1970s and 80s due to poor water quality associated with agriculture and urbanization. The Lake Simcoe Fisheries Assessment Unit (LSFAU) uses long-term monitoring data to assess the current status and changes through time in the coldwater fish community of Lake Simcoe. From the year 2004 to 2012 the LSFAU observed an increase in the relative abundance of both wild Lake Whitefish and Cisco, which suggests the populations may be recovering. The observed increases occurred despite potentially negative influences such as the presence of Rainbow Smelt (Osmerus mordax) and annual Lake Trout (Salvelinus namaycush) stocking. The Lake Whitefish and Cisco populations both produced two successful (strong) years of recruitment in 2004 and 2008 and recent data suggests 2012 was also successful for Cisco. These findings suggest that habitat and water quality conditions in Lake Simcoe have improved and may be favourable for coldwater fish reproduction and recruitment. Here we characterize the status of the recovering Lake Whitefish and Cisco populations using several metrics, including relative abundance, year class success, size at age, and growth. *Keywords: Recruitment, Fish populations, Fisheries.*

DOMSKE, H.M.[1] and TEPAS, K.[2], [1]NY Sea Grant, 228 Jarvis Hall, SUNY Buffalo, Buffalo, NY, 14260-4400; [2]IL/IN Sea Grant, USEPA GL National Program Office, 77 W. Jackson Blvd., G17J, Chicago, IL, 60604. **Transferring Shipboard Science to the Classroom.**

The Center for Great Lakes Literacy (staffed by Great Lakes Sea Grant Network's education specialists) has a long-term partnership with the USEPA to provide a unique learning experience for educators aboard their research vessel, the R/V Lake Guardian. This presentation will provide an overview of the annual cruise that brings 15 teachers from across the basin together for a week-long voyage on the waters of one of the Great Lakes each summer. During that week, educators work alongside scientists collecting samples while learning about that particular lake's biology, chemistry and geology; as well as current issues such as invasive species. They also spend time learning about the Great Lakes curriculum and other resources available for educators. This shipboard science experience helps to facilitate collaboration between scientists and educators, as well as enhance the teachers' capabilities in science. Once they return to their classrooms, the educators are tasked with infusing the Great Lakes into their curriculum. Examples of how educators transferred the knowledge and experience back into the classroom will be shared. *Keywords: Environmental education, Public education.*

DONOVAN, M.M. and HIGGS, D.M., Department of Biological Sciences, University of Windsor, Windsor, ON, N9B 3P4. **Variation in the call structure of male round goby (*Neogobius melanostomus*) and relationship to body morphometrics as a potential honest signal.**

Acoustic communication can serve as a means of identifying conspecifics from a distance, locating potential mates and assessing the quality of a potential mate. Calling behaviour can also be exploited by humans to determine the presence or absence of the species calling. In the current study, we examine the variability in the call structure of the male round goby and the use of the call for identifying, locating and assessing the quality of the male. Males were isolated and recorded with a hydrophone in the absence and presence of a reproductive female. Three types of calls were recorded: a short pulse consisting of 1-2 pulses, a pulse train characterized by 3 or more pulses and a growl call. Calls were analyzed in Adobe Audition 3.0 for duration, number of pulses, dominant frequency and interpulse interval and these characteristics were compared against total length, head width, body weight, gonad weight and gonadosomatic index (GSI). Preliminary data analysis shows a significant positive correlation between total length and dominant frequency, but no significant relationships between other call structure characteristics and morphometrics. Characterization of these calls will allow for tracking of round goby colonization and location of critical spawning grounds in a remote sensing context. *Keywords: Acoustics, Round goby, Fish behavior.*

DORIS, P.J.[1] and BALL, B.[2], [1]OMAF and MRA, 95 Dundas Street East, Brighton, ON, K0K 1L0; [2]OMAF and MRA, 63 Lorne Ave., East, Suite 2B, Stratford, ON, N5A 6S4. **Soil testing through the H-3 project: a success story and effects of season, tillage, tile drains on P and sediment losses.**

The H-3 project provides support to collect the soil samples for nutrient availability in east central Ontario. Farmer workshops explain the results, provide farm maps and assist with crop nutrient budgeting. Farmer response has exceeded original forecasts with 68 farmers participating and over 400 samples sent to the lab. Results indicate that approximately 62 percent of sampled fields have a soil phosphorus (P) of 20 ppm or lower (i.e. moderate to high probability that crops grown in these fields will be responsive to P supplementation). By contrast, 23% of fields tested for available soil P would be high enough to expect no response to additional P. In a separate trial, effects of tillage, nutrient type, presence of subsurface drainage and seasonality were evaluated in terms of effect on nutrient and sediment losses from agricultural fields. Nutrient losses were highest during rain/snow-melt events in the winter with one 50mm rainfall/snowmelt event accounting for over 80% of overland sediment and P losses (particulate P + dissolved organic P). This single event accounted for 28% of P losses through field tile drains and 20% of sediment losses via tiles. Minimum tillage reduced P losses by 6-fold and sediment losses by 3-fold compared to conventional tillage. *Keywords: Phosphorus, Nutrients, Sediment transport.*

DOVE, A.[1] and CHAPRA, S.C.[2], [1]Water Quality Monitoring and Surveillance, Environment Canada, Burlington, ON, L7R 4A6; [2]Civil & Environmental Engineering, Tufts University, Medford, MA, 02155. **Long-term Trends of Nutrients and Trophic Response Variables for the Great Lakes.**

Based primarily on data collected over the past four decades by Environment Canada, long-term trends of eutrophication-related variables are developed for the offshore waters of the Laurentian Great Lakes. Trends of spring concentration are reported for the major nutrient species: phosphorus [total phosphorus (TP), and soluble reactive phosphorus (SRP)]; nitrogen [total oxidized nitrogen (NO3/NO2), and ammonia nitrogen (NH3)]; and silica [biogenic silicon (SiO2)]. Summer trends of surface chlorophyll a and Secchi depth are developed as indicators of the lakes' trophic responses. The results indicate that phosphorus

has declined significantly in all the lakes, whereas nitrogen and silica have both increased. Along with documenting the impact of the 1978 Great Lakes Water Quality Agreement and the introduction of Dreissenids on offshore conditions, the results also demonstrate that the offshore waters are now overwhelmingly phosphorus limited, which supports the conclusion that controlling phosphorus remains the only option for managing the eutrophication of the Great Lakes offshore waters. *Keywords: Chlorophyll, Eutrophication, Nutrients, Secchi depth, Water quality, Trends.*

DRIEDGER, A.[1], DÜRR, H.[1], MITCHELL, K.[1], LYANDRES, O.[2], CROSS, J.[2], and VAN CAPPELLEN, P.[1], [1]University of Waterloo, 200 University Ave. W., Waterloo, ON, N2L 3G1; [2]Alliance for the Great Lakes, 150 N. Michigan Ave. Suite 700, Chicago, IL, 60601. **Mapping Marine Debris in the Great Lakes.**

Anthropogenic marine debris is an increasing environmental concern in the Great Lakes, affecting both open-water and beach environments. Debris is dominated by consumer and industrial plastics that are slow to degrade and known to cause several adverse environmental and socioeconomic impacts. Greater effort to characterize the spatial and temporal distribution of debris is important for developing best management practices. To date, few open-water and beach survey results reporting debris conditions in the Great Lakes have been published. However, volunteer-led beach surveys have helped fill this void. The spatial and temporal distribution of marine debris on Great Lakes' beaches were analyzed using Adopt-a-BeachTM volunteer-collected data from 2008 to 2012 provided by Alliance for the Great Lakes. In 2012, the highest ratio of plastic to non-plastic debris occurred in Lake Erie. Offshore, marine debris is known to accumulate in areas of converging surface flows. Hourly surface water velocity data from GLERL's GLCFS are being used to calculate surface water convergence and subsequently predict where debris is more likely to accumulate (2 km resolution). This information may help improve cleanup of debris by focusing efforts on areas with the highest debris counts. *Keywords: Microplastics, Spatial distribution, Water currents.*

DROUILLARD, K.G.[1], O'NEIL, J.A.[1], SUN, X.[1], and JOHNSON, T.B.[2], [1]Great Lakes Institute for Environmental Research, University of Windsor, Windsor, ON, N9B3P4; [2]Glenora Research Station, Ontario Ministry of Natural Resources, Picton, ON. **Use of PCBs as metabolic tracers to estimate field metabolic rate of round goby (Neogobius melanstomus) during temperature acclimation.**

A chemical depuration method was used to estimate field metabolic rates (FMR) of round gobies held in mesocosm tanks and subject to a fall/winter seasonal temperature change. Round gobies were collected from three Great Lakes populations including Lake Huron, Lake St. Clair and Lake Ontario and housed at the University of Windsor in communal tanks. In early fall, fish from each population were dosed with a set of metabolic tracer compounds consisting of polychlorinated biphenyls which vary in hydrophobicity and are not present in the environment. Fish were held communally in tanks receiving water at in-situ temperature from the Detroit River and allowed to depurate PCBs over 90 d. Water temperatures dropped from an initial temperature of 18.5 to 2.8°C. A toxicokinetic PCB depuration model was used to translate measured chemical elimination rates into gill ventilation rates which were subsequently converted into an estimate of oxygen consumption rate by tank held fish. Field metabolic rates were estimated to range from 0.40-0.51 kJ/g BW/d across the three populations. There were no significant differences in FMR between populations. The FMR/SMR ratio averaged 2.45±0.52 implying that acclimation costs contribute to overall metabolic budgets of fish. Technique assumptions related to PCB-tracer/FMR models are evaluated. *Keywords: Bioenergetics, Invasive species, Metabolism.*

DUFOUR, M.R.[1], QIAN, S.S.[1], MAYER, C.M.[1], VANDERGOOT, C.S.[2], TYSON, J.T.[2], KOCOVSKY, P.M.[3], KRAUS, R.T.[3], and WARNER, D.M.[4], [1]University of Toledo - Lake Erie Center, 6200 Bayshore Rd., Oregon, OH, 43616; [2]ODNR Division of Wildlife - Sandusky Fish Research Unit, 305 E. Shoreline Dr., Sandusky, OH, 44870; [3]USGS - Lake Erie Biological Station, 6100 Columbus Ave., Sandusky, OH, 44870; [4]USGS - Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105. **Coupling hyrdoacoustic and gill net surveys: Getting by with a little help from my Bayesian friends.**

Lake Erie walleye (*Sander vitreus*) are difficult to monitor, however coupling hyrdoacoustics with current gill net surveys may lead to improved sampling and management. Understanding the relationship between the two sampling methods remains an obstacle to extending surveys with hydroacoustics. We have collected hydroacoustic data from Lake Erie's western and central basins in concert with ODNR-DOW and USGS gill net surveys. Paired data have been analyzed with a Bayesian hierarchical bivariate normal model. Factors that may influence the relationship between sampling methods have been considered in the model including; gear avoidance, vertical migrations, probability of encounter, small scale migrations, and fish community structure. This analysis will allow the conditional inference of gill net abundance estimates from future expanded hydroacoustic survey data; translating information back to the currency used in stock assessment and management. Additionally, a

Bayesian analysis allows the flexibility to update the established relationship with future sampling as we recognize that transitioning ecosystems may lead to changes in statistical relationships. Ultimately, this study sets the foundation for researchers to expand survey coverage leading to improved understanding of walleye ecology. *Keywords: Walleye, Hydroacoustics, Mathematical models.*

DUFOUR, M.R.[1], MAY, C.J.[2], PRITT, J.J.[1], ROSEMAN, E.F.[3], MAYER, C.M.[1], LUDSIN, S.A.[2], MARSCHALL, E.A.[2], FRAKER, M.E.[2], DAVIS, J.J.[4], MINER, J.G.[4], QIAN, S.S.[1], VANDERGOOT, C.S.[5], and TYSON, J.T.[5], [1]University of Toledo, Toledo, OH, 43606; [2]The Ohio State University, Columbus, OH, 43212; [3]USGS, Great Lakes Science Center, Ann Arbor, MI, 48105; [4]Bowling Green State University, Bowling Green, OH, 43403; [5]Ohio Department of Natural Resouces, Division of Wildlife, Sandusky, OH, 43440. **Diversity in a Multi-Stock System: Temporal and Spatial Portfolio Effects in Lake Erie Walleye Production.**

Geographically distinct spawning stocks can generate population stability by increasing resiliency to environmental change. Stocks may respond differently to environmental change due to variation in habitat-specific responses. Differential responses among stocks may generate a "portfolio effect" by maximizing the ratio of spawning production to risk (i.e. poor production) through diversification. We compared larval walleye (*Sander vitreus*) production from three tributaries (Detroit, Maumee, and Sandusky Rivers) and the open-lake reef complex of western Lake Erie over several years (1994, 1995, 2011-2013). The reefs produced more larval walleye than all tributaries combined, but reef production was highly variable. In years when reef production was low, river production made substantial contributions, partially buffering reduced contribution from the reefs. The Detroit and Maumee Rivers produced relatively consistent numbers of larval walleye, whereas production from the Sandusky was more variable. Reef and river stocks responded differently to changing environmental conditions and climate, indicating that production risk is diversifiable. Appropriate investments, such as stock-specific management and protection and restoration of in-river habitat may decrease variation in inter-annual production of larval walley. *Keywords: Walleye, Fish management, Lake Erie.*

DUHAIME, M.[1], RULE WIGGINTON, K.[1], BELETSKY, D.[1], RIOS-MENDOZA, L.[2], CHEN, Z.[1], BELETSKY, R.[1], DALEY, J.[1], SANO, L.[1], and BURTON, A.[1], [1]University of Michigan Water Center, 214 S. State St., Suite 200, Ann Arbor, MI, 48104;

[2]University of Wisconsin-Superior, Barstow Hall 202 Belknap and Catlin, Superior, WI, 54880. **A Multidisciplinary Approach to Assess the Impact of Microplastics on Laurentian Great Lakes Ecosystem Health.**

Plastic contamination is one of the most ubiquitous changes to our planet and has recently been documented in the Great Lakes at the highest concentrations on earth. Our research uses a cross-disciplinary and multiscale approach to help define the ecological and environmental health risks of plastics in the Great Lakes. We will develop novel methods of MS analytical techniques, explore the ecological risk of plastics from both the external contamination (plastic-bound organic pollutants) and physical contamination of plastics, and improve circulation models to help predict transport of plastics through the Laurentian system. *Keywords: Ecosystem health, Great Lakes basin, Microplastics.*

DUNLOP, E.S.[1] and MILNE, S.W.[2], [1]Ontario Ministry of Natural Resources, Peterborough, ON; [2]Milne Technologies, P.O. Box 237, Keene, ON, K0L 2G0. **Using fisheries acoustics to study Lake Simcoe's pelagic fish community.**

The pelagic fish community makes up an important component of the Lake Simcoe food web. Pelagic fish provide a key link between the plankton populations that they feed on, and the top predators, such as lake trout, that rely on them for food. The pelagic fish community of Lake Simcoe has undergone dramatic changes over the past 50 years. For example, the cisco population was much more abundant in the past, before undergoing declines in the 1980s. In response to the population collapse, the once large recreational fishery for cisco was closed in 2001. Rainbow smelt, a non-native pelagic prey fish, were first detected in Lake Simcoe in the early 1960s, potentially causing further disruption to the fish community. In support of the Lake Simcoe Protection Plan, fisheries acoustics surveys were conducted in 2011-2013 to characterize the pelagic fish community of Lake Simcoe. Results show a substantial increase in pelagic fish density between 2011 and 2012, mostly due to a strong year class of cisco that was spawned in the fall of 2011. The data being collected by this fisheries acoustics program are being used to assess the recovery status of the cold water fish community, to meet fish community objectives, and to support management decisions related to the re-opening of the cisco fishery. *Keywords: Acoustics, Hydroacoustics, Lake Simcoe.*

DUNLOP, E.S.[5], EBENER, M.P.[2], HE, J.X.[3], LENART, S.[4], COTTRILL, A.R.[1], DAVIS, C.[1], and MOHR, L.C.[1], [1]Upper Great Lakes Management Unit, Ontario Ministry Natural Resources, Owen Sound, ON, N4K 2Z1; [2]Chippewa Ottawa Resource Authority, Sault Ste.

Marie, MI, 49783; [3]Alpena Fisheries Research Station, Michigan Department Natural Resources, Alpena, MI, 49707; [4]Alpena Fish and Wildlife Conservation Office, U.S. Fish and Wildlife Service, Alpena, MI, 49707; [5]Ontario Ministry of Natural Resources, 2140 East Bank Drive, Peterborough, ON, K9J 7B8. **The Response of Lake Whitefish to Rapid Changes in the Structure and Function of the Lake Huron Food Web.**

Lake whitefish in Lake Huron have shown marked changes over the past decade in key population-level and individual-level properties. Most notably, recruitment declines have been observed in several parts of the lake. Growth and condition have also declined, but have shown signs of improvement in the past few years in some areas. Many of the changes, however, began before the prominent ecosystem change of 2003, suggesting that other factors have contributed to the declines. Here, we present trends in growth, condition, and recruitment of whitefish from different regions of Lake Huron. We show that the magnitude of the response varies by region and has been most pronounced in Northern Main basin and southern Georgian Bay. We further explore potential reasons why the trends have been more pronounced in some areas versus others. *Keywords: Growth, Recruitment, Maturity.*

# E

EATON, L.A.[1], RISENG, C.M.[1], NALEPA, T.F.[2], and GLYSHAW, P.W.[1], [1]University of Michigan, School of Natural Resources and Environment, 440 Church St., Ann Arbor, MI, 48109; [2]University of Michigan - Water Center, 214 S. State St., Suite 200, Ann Arbor, MI, 48104. **Spatial and Temporal Trends in the Nearshore Zone of Thunder Bay, Lake Huron.**

Dreissenid mussels, both Zebra (*Dreissena polymorpha*) and Quagga (*Dreissena rostriformis bugensis*), have proven to be some of the worst aquatic invaders in the Great Lakes ecosystem and in some locations they are thought to have altered nutrient dynamics. However, less is known about how Dreissenid mussels alter components of the benthic community in rocky substrates. This study aims to analyze the benthic community in the rocky substrate of the nearshore zone (<3m) and compare densities, biomass, and diversity to benthic communities associated with mussels at offshore sites in Lake Huron. Benthic invertebrates, dreissenid mussels, and macrophytes were collected by divers at six nearshore-hard-substrate sites in Thunder Bay, Lake Huron. Samples were collected in spring, summer, and fall in 2012, and in spring and summer in 2013. Compared to the offshore soft sediment sites in Lake Huron, the nearshore zone had significantly higher Quagga mussel density per site. Addi-

tionally, the benthic invertebrate taxonomic orders Ephemeroptera and Tricoptera were found at every nearshore site, whereas they were rarely found at the offshore sites in Lake Huron. *Keywords: Dreissena, Benthos, Lake Huron.*

EHINGER, T.J., Dept Biological Sciences, University of Wisconsin - Milwaukee, Milwaukee, WI, 53201. **Using Video Art to Visualize Vulnerability and Vitality of the Commons.**

The science of sustainable development has evolved over the past 40 years from early notions of steady-state resource management toward concepts of dynamic social-ecological systems. Effectively using these concepts as a part of public discussion is often difficult, since few people possess functional literacy with all the diverse concepts, patterns, and processes relating to human-environmental systems and feedbacks among biophysical, social and institutional domains. The RIVERPULSE video art project was originally developed to use art and technology to interpret scientific water quality data for students and the general public - showing the inter-connectivity of people and their communities in the Milwaukee River Basin (http://www.riverpulse.org/). This paper will present an extension of the RIVERPULSE concept to more directly illustrate the practical interconnections among the "Three Pillars" ("People, Planet, Prosperity") as they relate to the social-ecological resilience of watersheds. In particular, the goal is to use artistic visualization as a common language to show the health of a "Water Commons" and its capacity for to cope with uncertainty and adjust to change. Developing a common language is the first step in building a shared understanding and vision for action frameworks for water sustainability. *Keywords: Indicators, Watersheds, Education.*

EIMERS, M.C., Department of Geography, Trent University, Peterborough, ON, K9J7B8. **Urban cover effects on streamflow across the Greater Toronto Area.**

Increases in urban cover can have dramatic effects on stream flow by altering the flow paths and rate of runoff delivery to streams. In this study, long-term (1967-2007) runoff records from five rural streams (<12% impervious cover) and four urban streams (>54% IC) that span the Greater Toronto Area were contrasted with respect to the frequency of high flow and low flow events, daily flow variability and the relative proportion of quickflow versus baseflow at both the seasonal and annual time scales. Surprisingly, there were few consistent differences in either total flow or low flow frequency between urban and rural streams when metrics were computed at the annual time scale; however, impervious cover had a dramatic impact on the frequency of high flows during the summer and fall. As expected, urban streams had a greater proportion of quickflow compared with baseflow runoff, and differences were most substantial in the summer and fall. Winter and spring runoff metrics were more similar amongst urban and rural streams, probably because seasonal snow cover and snow melt tend to 'homogenize' impervious and pervious surfaces. More quickflow/high flow runoff events in urban streams as well as decreases in baseflow have implications for pollutant delivery as well as the maintenance of environmental flows. *Keywords: Urban watersheds, Hydrologic cycle, Urbanization.*

EL-SHAARAWI, A.[1] and HADI, A.S.[2], [1]National Water Research Institute, Burlington, ON, Egypt; [2]American Universityt in Cairo, Cairo, Egypt. **Dave Dolan: A life Devoted to Quantitative Research on the Great Lakes.**

We are celebrating Dave's contributions in the quantitative research on water quality of the Great Lakes. We will discuss his work on load estimation of nutrients and toxic contaminants, where he used the Beale's ratio estimation which is based on the correlation between the water flow and concentration of a pollutant to enhance the efficiency (reduce bias and variance) of the estimated load. Here we extend this work using the theory of prediction under the finite population framework. We shall also discuss Dave's spatial estimation of water quality maps based on water distance correlation which is a major step forward in the characterization of the spread of pollution in the Great Lakes aquatic environment. *Keywords: Environmental statics, David Dolan.*

ENDSLEY, K.A.[1], SAYERS, M.[1], SHUCHMAN, R.A.[1], BROOKS, C.N.[1], and LESHKEVICH, G.[2], [1]Michigan Tech Research Institute, 3600 Green Ct., Ste. 100, Ann Arbor, MI, 48105; [2]NOAA / GLERL, 4840 S. State Rd., Ann Arbor, MI, 48108. **The Great Lakes Optical Properties Geospatial Database.**

The Great Lakes Optical Properties Geospatial Database (GLOPGD) is a representation of in situ optical and water quality measurements made in all five of the Great Lakes over the last 15 years. This geospatial database has been collected by various leading groups and institutions such as the NOAA Great Lakes Environmental Research Lab, the Upstate Freshwater Institute, the Michigan Tech Research Institute (MTRI) and others in the Great Lakes to help better understand long term changes due to anthropogenic forcing, climate change, and invasive species. This is the first time that these data have been made widely available to Great Lakes scientists and stakeholders through the web (glopgd.org). GLOPGD contains spatially-located optical data such as the diffuse attenuation coefficient

(Kd), Remote Sensing Reflectance (Rrs), KdPAR, absorption, backscatter, and photic zone depth as well as many other parameters. Water chemistry data includes concentration measurements of chlorophyll a, dissolved organic carbon (DOC), total and volatile suspended solids (TSS and VSS) as well as colored dissolved organic matter (CDOM). GLOPGD allows users to "map" these available parameters to provide better access to area of interest data sets. Queried data will available for download in a number of file types including shapefiles, KML, and CSV. *Keywords: Remote sensing, Water quality, Biogeochemistry.*

ESSELMAN, P.C.[1], STEVENSON, R.J.[2], KENDALL, A.D.[3], MARTIN, S.L.[3], and HYNDMAN, D.W.[3], [1]USGS Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105; [2]Zoology Department, Michigan State Univeristy, 288 Farm Ln. Room 203, East Lansing, MI, 48824; [3]Department of Geological Sciences, Michigan State University, 288 Farm Ln. Room 206, East Lansing, MI, 48824. **Statistical estimation of landscape contributions of total phosphorus loads to the entire U.S. coastal zone of the Great Lakes.**

High phosphorus loads from rivers have been identified as an important driver of excessive algal growth in downstream receiving waters such as the Great Lakes, leading to calls for development of nutrient management targets under the Great Lakes Water Quality Agreement (GLWQA) of 2012. We describe a statistical approach that estimates summer daily total phosphorus loads for all 1,535 river mouths discharging to the U.S. Great Lakes coastline. Our load estimates were made by multiplying predictions from a boosted regression tree model of river nutrient concentrations by area-weighted extrapolated daily discharge at river mouths. The boosted regression tree model was trained to predict nutrient concentrations from catchment land cover, geology, and lagged precipitation. Predicted daily loads correlated very well to independent measured loads near 41 Michigan river mouths with high precision (R2 = 0.89) and little bias. We used our model to predict summer loads (May to September) from the period between May 2000 and September 2012, enabling the ranking of watersheds for relative and absolute loads. Five of the top-20 loading rivers discharged into the western basin of Lake Erie, which has a history of recent harmful algal blooms. Our load estimates may provide a basis exploration of nutrient targets at the basin-scale. *Keywords: Phosphorus, Watersheds, Model testing.*

ESSIAN, D.[1], MORASKA LAFRANCOIS, B.[2], and LEONARD, J.B.K.[1], [1]Biology Department, Northern Michigan University, Marquette, MI, 49855; [2]National Park Service, Ashland, WI, 54806. **Diets of Botulism Affected Piscivorous Birds on Lake Michigan.**

Dreissenid mussels and round gobies (*Neogobius melanostomas*) are dominant organisms in the nearshore benthic communities of the Great Lakes. These species are also important prey items of several bird species and may play a role in the transfer of type E botulism toxin (BoNT/E) to piscivorous birds. Small round gobies feed mostly on macroinvertebrates, while larger gobies have a tendency to feed on dreissenids. Therefore, determining the mean size of gobies consumed by botulism-affected birds may help clarify how BoNT/E is being transferred through the food web of affected birds. We examined the diet composition and prey size of 38 botulism-affected loon (*Gavia immer*) and 13 cormorant (*Phalacrocorax auritus*) carcasses collected from Lake Michigan beaches in 2007-2012. The minimum number of gobies consumed was higher in BoNT/E-positive vs. BoNT/E-negative loons (13.5 ± 2.4 vs 6.0 ± 1.4) and cormorants (5.9 ± 4.1 vs 0.2 ± 0.1). The mean estimated length of round goby found in the stomachs of BoNT/E positive loons and cormorants was 100.5 mm ± 2.4 mm and 110.5 mm ± 32.2 mm, respectively. The data suggest that dreissenid mussels or related microhabitats may be an important vector for BoNT/E, likely through the round goby, in piscivorous birds. *Keywords: Avian ecology, Round goby, Dreissena.*

ESSIG, R.R., TROY, C.D., CHERKAUER, K.A., CHAUBEY, I.D., and TAN, J., School of Civil Engineering, Purdue University, 550 N Stadium Mall Dr, West Lafayette, IN, 47907. **Lake Michigan Tributary Nutrient Loading: A spatial and temporal trend assessment for 2011-2013.**

Quantifying temporal and spatial nutrient loading to Lake Michigan has been a priority for scientists, and past research developed a lake-wide survey of nutrient sources and sinks, but estimations of tributary contributions were limited due to poor temporal resolution of sampling. Additionally, limited data resolution resulted in the inability to quantify nutrient loading during episodic events potentially leading to the underestimation of annual values. This study has three primary objectives: (1) provide updated tributary nutrient loading for 2011-2013 using higher resolution data, (2) conduct temporal and spatial analysis of the delivery of nutrient loading in order to help identify most productive sampling methodologies, and (3) detail the importance of episodic loading. Analysis conducted includes the estimation of seasonal and annual nutrient loading for 12 tributaries on Lake Michigan as well as loading distribution analysis in order to quantify the effect of episodic loading for each river. Results indicated strong contributions of nutrients occurring during the late win-

ter and early spring when storm events are typically strongest. Loading analysis also indicated that total nitrogen acts the most chemostatic of the nutrients researched while TSS is the least. *Keywords: Nutrients, Lake Michigan, Tributaries.*

EVANS, D.O., KOPF, V.E., and RENNER, V.E., Ontario Ministry of Natural Resources, Trent University, Peterborough, ON, K9J 7B8. **Shifting Thermal Regime is Delaying Spawning of Lake Trout in Lake Simcoe.**

Spawning time of lake trout in Lake Simcoe appears to have been delayed in recent decades by a shift in the lake thermal regime linked to climate change. We describe changes in the thermal regime and spawning time of lake trout and assess potential causal factors for both. Spawning time was monitored using trap nets installed at southern and northern locations during early October, prior to the onshore movement of lake trout, and fished until late November, 1976 to 2003. Nets were lifted on average every 3-4 days and a total of 17,092 and 24,841 lake trout were captured. Cumulative catch curves for males and females, by stage of maturity, were used to characterize the spawning runs. Atmospheric temperature data and lake thermal characteristics, including seasonal epilimnetic and hypolimnetic temperature trends and thermocline dynamics were analysed. The total run duration averaged 35 and 37 days at our two study sites. Spawning time was delayed by about 10-14 days from the 1970s to 2000s and was correlated with warmer atmospheric and epilimnetic temperatures. Changing lake transparency and climate change appear to be key drivers. The management and policy implications of spawning time delay are important because of the potential costs of decline or even loss of this keystone top predator within the lake ecosystem. *Keywords: Lake trout, Spawning time, Fish behavior, Thermal regime, Climate change.*

EWING, G.[1], DEMARCHI, C.[2], LOFGREN, B.M.[3], WANG, J.[3], and BAI, X.[4], [1]Department of Civil and Environmental Engineering, University of Michigan, Ann Arbor, MI, 48109-2125; [2]Department of Earth, Environmental, and Planetary Sciences, Case Western Reserve University, Cleveland, OH, 44106-7216; [3]Great Lakes Environmental Research Laboratory, Oceanic and Atmospheric Administration, Ann Arbor, MI, 48108-9719; [4]Cooperative Institute for Limnology and Ecosystems Research, University of Michigan, Ann Arbor, MI, 48109-1041. **Comparing Coupled Hydrosphere-Atmosphere Research Model (CHARM) Simulation of Great Lakes Water Temperature to the FVCOM Model Simulation and Experimental Data.**

The Coupled Hydrosphere-Atmosphere Research Model (CHARM) is a Regional Climate Model developed at the NOAA Great Lakes Environmental Research Laboratory for hydro-climatological studies in the Great Lakes basin. CHARM features a 40-km spatial resolution and an explicit representation of the Great Lakes thermal structure with a modified Hostetler formulation. Although primarily used for understanding the possible impacts of Climate Change on lake water balance, recently CHARM projections of water temperature for future climate scenarios have been used to study the impact that climate change may have on Great Lakes fish population. In this study, we tested CHARM capabilities of representing the Great Lakes water temperature when driven by reanalysis meteorological boundary conditions and boundary conditions generated by the Canadian General Circulation Model 3. Comparison was done for surface temperature and vertical profiles in the five major lakes against temperature simulations by the 3-Dimensional lake thermodynamic model FVCOM and observed data. *Keywords: Atmosphere-lake interaction, Climate change, Computer models.*

# F

FAHNENSTIEL, G.L.[1], YOUSEF, F.[2], SAYERS, M.[1], POTHOVEN, S.A.[3], and SHUCHMAN, R.A.[1], [1]Michigan Tech Research Institute, 3600 Green Ct., Ste. 100, Ann Arbor, MI, 48105; [2]Michigan Technological University, 1400 Townsend Dr., Houghton, MI, 49931; [3]NOAA/GLERL, 1431 Beach St., Muskegon, MI, 49441. **Long-term trends in lake-wide phytoplankton productivity in the Upper Great Lakes: 1998-2013.**

Lake-wide estimates of phytoplankton productivity in the Great Lakes are almost non-existent due to their large size and limited sampling. In order to overcome these limitations, a field-validated remote sensing approach was used to estimate lake-wide phytoplankton productivity for lakes Superior, Huron and Michigan. The Great Lakes Production Model (GLPM), a slight modification of original Fee model, was used to provide areal and volumetric estimates of primary production using satellite-derived measures of PAR, KdPAR, and chlorophyll. Photosynthetic parameters were estimated using an empirical model based on historical measurements and simple input variables (i.e., temperature, Julian Day, depth, season, etc.). Modeled production estimates revealed large production changes in lakes Huron and Michigan but not Lake Superior. These changes and their relationship to important drivers (i.e., nutrients, mussels, climate change, etc.) will be discussed. *Keywords: Productivity, Long term trends, Phytoplankton.*

FANG, J.W. and WALLACE, A.M., Toronto and Region Conservation Authority, 5 Shoreham Drive, Downsview, On, M3N 1S4. **The Assessment of Rusty Crayfish (*Orconectes rusticus*) Populations in the Greater Toronto Region.**

Rusty crayfish (*Orconectes rusticus*) are an aquatic invasive species in Ontario waterways. They were first found in Ontario in the 1960s and in the Toronto Region in 1983. To help understand the ecosystem vulnerability to the invasive rusty crayfish, Toronto and Region Conservation Authority (TRCA) conducted Rusty Crayfish Monitoring in conjunction with its Regional Watershed Monitoring Program in 2012 and 2013. Monitoring data collected by TRCA showed that rusty crayfish have become the dominant crayfish species in both the Rouge River and Duffins Creek watersheds. This presentation covers the results from this study including: 1. The presence and spread of the rusty crayfish in several TRCA watersheds. 2. The overall health conditions of the rusty crayfish, including abundance, sex ratio, and length-weight relationship. 3. A comparison of two sampling techniques (kick-and-sweep and backpack electrofishing) to assess their efficiency in early detection of the rusty crayfish. *Keywords: Invasive species, Monitoring, Crustaceans.*

FARMER, T.M.[1], MARSCHALL, E.A.[1], DABROWSKI, K.[2], and LUDSIN, S.A.[1], [1]The Ohio State University, Department of Evolution, Ecology, and Organismal Biology, Aquatic Ecology Laboratory, 1314 Kinnear Road, Columbus, OH, 43212; [2]The Ohio State University, School of Environment and Natural Resources, Aquaculture Laboratory, 2021 Coffee Rd, Columbus, OH, 43210. **Climate Warming Negatively Affects Lake Erie Yellow Perch Reproductive Success and Recruitment.**

Although climate warming is expected to positively affect temperate fishes by improving thermal conditions for growth during fall and spring, declines in reproductive success following a shortened winter may counter such positive effects. Herein, we investigated the effect of short, warm winters on reproduction and recruitment of Lake Erie yellow perch (*Perca flavescens*; a coolwater temperate fish), a species that develops its ovaries during winter. Based on previous research, which documented reduced spawning success and weak recruitment events following warm winters, we hypothesized that warm winters lead to failed recruitment by disrupting reproductive development (i.e., gametogenesis). To test this hypothesis, we conducted a controlled laboratory experiment (2011-2012) in which yellow perch females were exposed to a long (110 days > 5ºC) or short (50 days > 5ºC) winter (n=6 replicates/treatment). Our experiment revealed reduced egg size, egg hatching success, and egg and larval quality from females exposed to a short versus short winter. Ultimately, our research offers a previously unrecognized mechanism by which climate change can negative-

ly affect reproductive success, and subsequently recruitment, in temperate freshwater fish populations. *Keywords: Yellow perch, Recruitment, Climate change.*

FAUST, M.D.[1], BINDER, T.R.[2], MIDA HINDERER, J.[1], and KRUEGER, C.C.[3], [1]Great Lakes Fishery Commission, 2100 Commonwealth Blvd, Suite 100, Ann Arbor, MI, 48105; [2]USGS Hammond Bay Biological Station, 11188 Ray Road, Millersburg, MI, 49759-9481; [3]Michigan State University, 1405 S. Harrison Road, East Lansing, MI, 48823. **Feasibility of electrosedation as an alternative to chemical sedation of lake trout, *Salvelinus namaycush*.**

Electricity has been evaluated as an alternative to chemical sedatives (e.g., tricaine methanesulfonate, carbon dioxide, etc.) in fisheries since the 1970s due to concerns over short and long term effect of chemicals. We evaluated the sedation effects of direct current, pulsed direct current, and dual-frequency pulsed direct current on lake trout. Our primary objective was to determine whether some combination of settings (i.e., duty cycle, frequency, voltage, and waveform) using a Portable Electroanesthesia System (Smith-Root, Inc., Vancouver, Washington) will sedate 100% of lake trout for longer than 250 s, but not longer than 600 s, when fish are exposed to electricity for less than 60 s. Additionally, we evaluated lethal (i.e., mortality) and sub-lethal (i.e., anaerobic swimming capacity, condition, vertebral column injury) effects. This is one of the first studies to quantify sub-lethal effects of electrosedation. *Keywords: Fish tagging, Fish management, Lake trout.*

FEISTHAUER, N.C., JOOSSE, P.J., and REID, D.K., Agriculture and Agri-Food Canada, 174 Stone Road W., Guelph, ON, N1G 4S9. **Using agri-environmental indicators to track changes in the risk of nutrient and sediment losses in the Lake Erie basin: I. Grand River Case Study.**

Agriculture and Agri-Food Canada has developed several agri-environmental indicator models for national reporting of trends in environmental risk and conditions in agriculture. Components of these national models can be utilized in a modular fashion to inform regional scale issues such as water quality in Lake Erie. The application of the source and transport components from the indicators for phosphorus, nitrogen and soil erosion has been piloted in a study of a Canadian sub-watershed of the Lake Erie basin, the Grand River watershed. By considering the sources and pathways separately for different potential nutrient forms and sediment, appropriate management actions can be inferred. The relative risk of loss of nutrient and soil from agricultural landscapes within the Grand River watershed was estimated for nitrogen, sediment and particulate and soluble phosphorus. The models utilize Census of Agriculture information since 1981, allowing a 30-year time series analysis of changes of risk on the landscape. This presentation will present the concepts and results used in the pilot study of the Grand River watershed. *Keywords: Nutrients, Agriculture, Phosphorus, Management.*

FENG, Y.[1], ATKINSON, J.F.[1], BOYER, G.L.[2], and VERHAMME, E.M.[3], [1]Department of Civil, Structural and Environmental Engineering, University at Buffalo, Buffalo, NY, 14260; [2]Department of Chemistry, SUNY College of Environmental Science and Forestry, Syracuse, NY, 13210; [3]LimnoTech, Ann Arbor, MI, 48108. **Identifying Nutrient Source for the 2010 Blue-green Algae Outbreak in Sodus Bay, NY via Modeling and Data Analysis.**

Blue-green algae outbreaks are an increasingly common eutrophication problem in the Great Lakes. In Sodus Bay, NY, a severe outbreak occurred just before Labor Day weekend in 2010, which shut down all water recreation, threatened human health, and greatly harmed the local economy. Although there was no monitoring program in place, there also was no known exceptional nutrient loading that would suggest the bloom resulted from actual runoff loading at that time. To complicate matters, Sodus Bay is a very shallow embayment, where algae are in competition with macrophytes. To evaluate the causes, a coupled hydrodynamic and ecological model was used to reconstruct the physical conditions, nutrient loading, and algal growth at the time of the outbreak. Additional data analysis was also used to incorporate macrophyte-algae interaction in the bay. Analyses to date indicate that macrophyte die-off may provide a source of phosphorus for algae uptake, and that this process would explain the observed initiation of the algal bloom in shallower, nearshore areas. By evaluating these processes for different years, the critical processes that provided the vital nutrient source for the 2010 outbreak under these conditions can be identified, and this information sets a viable foundation for seeking best management practices. *Keywords: Littoral zone, Macrophyte-algae interaction, Harmful algal blooms.*

FENG, Y.[1], ATKINSON, J.F.[1], BOYER, G.L.[2], and VERHAMME, E.M.[3], [1]Department of Civil, Structural and Environmental Engineering, University at Buffalo, Buffalo, NY, 14260; [2]Department of Chemistry, SUNY College of Environmental Science and Forestry, Syracuse, NY, 13210; [3]LimnoTech, Ann Arbor, MI, 48108. **Importance of Sediment Phosphorus Loading for Blue-green Algal Bloom in Sodus Bay, NY.**

Phosphorus loading is a critical factor that contributes to blue-green algal blooms in the Great Lakes. In Sodus Bay, New York, phosphorus loading in the spring from the watershed by agriculture practices is well recognized, whereas how phosphorus becomes available to the blue-green algae in the summer is unknown. A coupled hydrodynamic and water quality model was used to evaluate the role of different sources of phosphorus in a late August 2010 blue-green algal bloom in Sodus Bay, with emphasis on the subtle balance of the phosphorus concentration from different processes in the summer. Results of this analysis suggested that macrophyte die-off might have provided an important component of the phosphorus availability. This process is generally not included in most ecosystem models, and current results suggested that, at least in the case of Sodus Bay, it should be considered in future analyses. After ranking the contribution of various processes, loading reduction scenarios were tested to guide best management practices. *Keywords: Harmful algal blooms, Sediment load, Ecosystem modeling.*

FERA, S.A.[1], RENNIE, M.D.[2], and DUNLOP, E.S.[1], [1]Ontario Ministry of Natural Resources, Aquatic Research and Monitoring Section, Peterborough, ON; [2]Freshwater Institute, Department of Fisheries and Oceans, Winnipeg, MB. **The Effects of Food Web Changes on Lake Whitefish Growth, Diet, and Depth in Lake Huron.**

Dramatic change has occurred in Lake Huron's food web with the establishment of dreissenid mussels, the loss of Diporeia, and the crash of alewife. We sought to understand how dreissenids and several other factors have influenced feeding, depth, and growth of lake whitefish across Lake Huron. Growth trends and ∂13C and ∂15N ratios were analyzed from long-term collections of archived whitefish scales in five Lake Huron locations (Southampton, Cape Rich, Grand Bend, Detour Village, Cheboygan). We created growth models including available parameters that might contribute to variation in growth and diet (relative population abundance, temperature, dreissenid presence, alewife crash, year) and used variance partitioning to determine the independent effects of each parameter. Growth in the northern main basin was most driven by whitefish relative abundance, while Georgian Bay and southern main basin whitefish showed that food web changes (year, dreissenids, alewife) were the highest contributors to variance. Stable isotope analysis showed that ∂13C ratios increased in all locations, and ∂15N was depleted in all locations except Cheboygan, corresponding with dreissenid establishment. These changes are indicative of a dependence on nearshore prey items, which has potential implications for the productivity of the fishery. *Keywords: Long-term study, Fish diets, Growth, Isotope studies, Lake whitefish, Lake Huron.*

FERA, S.A.[1], ARNOTT, S.E.[2], and JOHNSON, T.B.[1], [1]Ontario Ministry of Natural Resources, Aquatic Research and Monitoring Section, Peterborough, ON; [2]Queen's University, Biology Department, Kingston, ON. **Gauging the Success of Outreach to Recreational Boaters and Anglers to Prevent the Spread of Aquatic Invasive Species in Ontario.**

To gauge how public participation in AIS spread prevention has changed in response to outreach tactics, we analyzed trends among three surveys of Ontario anglers in 1998, 2004 and 2009. In 2009, respondents relied on an increased diversity of AIS information sources compared to previous years, reflecting varying outreach tactics. Coincident with this, far fewer individuals identified a 'lack of knowledge' as the reason for not participating in prevention and an increasing number of individuals reported inspecting their boats after use. Nevertheless, other preventative boat washing strategies (pressure/hot water washing, physical removal) have not increased since the initial survey. We also identified that the main deterrents to proper bait disposal habits were primarily compassionate (not wanting to unnecessarily kill bait; providing food for fish). To help identify outreach strategies most likely to illicit desired behavioral changes, we interviewed AIS outreach coordinators across Great Lakes jurisdictions. Four types of awareness programs were classified (legacy, current, innovative initiatives, emerging), and we observed a trend towards increasingly targeted public education programs. A boat inspection program was identified as a crucial component of programs aiming to increase participation in AIS spread management. *Keywords: Recommendations, Management, Public participation, Invasive species, Public education.*

FERMANICH, K.J., PELEGRIN, A., and BAUMGART, P.D., University of Wisconsin - Green Bay, 2420 Nicolet Drive, Green Bay, WI, 54311. **Green Bay Watershed High Schools Contribute to Long Term Monitoring.**

Since 2003, high school student-teacher teams have been performing environmental monitoring of key tributaries in the Green Bay watershed as members of the Lower Fox River Watershed Monitoring Program. The program combines watershed education and the collection of quality scientific data with support from university, business, agency, and community groups. Seventy to 85 students and 17 teachers participate in the program each year. Students are from eleven high schools and the Green Bay Boys & Girls Club. The school-based teams have created a high quality, long-term database of nutrient, water quality, biological, and habitat conditions of their local streams. The student-generated database includes more than 2500 water quality measurements, 160 biotic indexes, 400 bird point counts and 130 amphibian observation points. Students use their data and field experiences to explore research and management questions in their communities and share their data at

an annual watershed symposium and at other community outreach events. This hands-on, problem-focused program develops and enhances scientific literacy and community stewardship which are critical to the long-term success of basin-wide restoration efforts and the sustainability of the Green Bay ecosystem. *Keywords: Citizen science, Water quality, Education, Green Bay.*

FERRER, D.L. and DELEO, P.C., American Cleaning Institute, 1331 L St NW, Suite 650, Washington, DC, 20005. **Geospatial data acquisition and management in the development of a web-based environmental exposure model for the Great Lakes basin.**

The American Cleaning Institute (ACI) is a trade association representing the cleaning products industry in the US. Cleaning products are typically disposed of "down-the-drain". To promote product stewardship and regulatory compliance for chemical suppliers and manufacturers of formulated products, an environmental fate model, iSTREEM®, was created. iSTREEM® is a web-based publicly available computer model that calculates the concentration of chemicals from consumer products disposed of "down-the-drain" in wastewater treatment plan influent, and effluent, in the mixing zone, and at the point of drinking water intake. iSTREEM® grants the users the option of loading the data into a map within the website depicting visually the chemical concentrations in the environment or receiving output in a tabular, downloadable format. Originally, iSTREEM® only represented the continental US but recently has been expanded to include Southern Ontario, Canada, thus incorporating a complete model for the entire Great Lakes basin. This presentation will include a discussion of the process of data acquisition and management for the incorporation of the Canadian datasets for flow and facilities (wastewater and drinking water) into the existing iSTREEM® model. In addition, comparison of model results to monitoring data will be provided. *Keywords: Exposure, GIS, Fate, Drinking water, Water quality.*

FETZER, W.W.[1], ROTH, B.M.[1], INFANTE, D.M.[1], and CLAPP, D.F.[2], [1]Department of Fisheries and Wildlife, Michigan State University, 480 Wilson Road, East Lansing, MI, 48824; [2]Charlevoix Fisheries Research Station, Michigan Department of Natural Resources, 96 Grant St., Charlevoix, MI, 49720. **Long-term Nearshore Fish Community Changes in Michigan waters of the Great Lakes.**

Ecosystem changes across the Great Lakes have likely increased the importance of nearshore ecosystems (<30 m depth) to lake-wide dynamics. The 2012 Year of Lake Huron Coordinated Science and Monitoring Initiative (CSMI) and other projects across the Great

Lakes provide new insights into how ecological dynamics are changing within lakes but also allow for comparisons across lakes. Here, we present a first attempt to understand how fish communities are changing within and across nearshore habitats in the Michigan waters of the Great Lakes, focusing on Lakes Huron and Michigan. These analyses take advantage of data collected through multiple gear-types (e.g. gillnets, bottom trawls, and trapnets), and provide an opportunity to address population-level responses across multiple life history stages. Trends are explored across locations and species to identify how context-dependent interactions influence population- and community-level responses to ecosystem perturbations. Our goal in presenting this research is to build collaborations with researchers throughout the Great Lakes and to improve standardization, communication, and data sharing at Basin-wide scales. *Keywords: Species composition, Fish, Coastal ecosystems.*

FIELDER, D.G.[1] and LISKAUSKAS, A.P.[2], [1]Michigan Department of Natural Resources, 160 E. Fletcher, Alpena, MI, 49707; [2]Ontario Ministry of Natural Resources, 1450 Seventh Avenue East, Owen Sound, ON, N4K 2Z1. **Recent Walleye Trends in Lake Huron.**

The profound fish community changes in Lake Huron have allowed for recovery of walleye in Saginaw Bay. Recent research efforts have focused on better understanding the scale and role of this native predator, not only in the bay but in the rest of Lake Huron's food web. Ontario walleye stocks do not emanate from a single source but a large number of rivers. Their status is variable with many showing declining recruitment, in contrast with Saginaw Bay. New stock assessment efforts have quantified the Saginaw Bay stock peak around 4 million (age 2+). Recent work suggests that, along with lake trout and lake whitefish, that walleye are one of three primary predators in the openwater fish community. Ongoing telemetry work has indicated that as many as half the adults are emigrating from the bay outside the spawning period. Research has identified four fisheries exploiting that stock (recreational, Ontario trapnet & gillnet, tribal gillnet (by-catch) and state-licensed trapnet by-kill) and modeling has allowed for these mortality sources to be quantified. Lastly a new simulation model gives clues as to how walleye may function in response to further ecological change or management options. These works and others will be drawn upon to examine the recent trends of walleye and its place in the evolving Lake Huron fish community *Keywords: Walleye, Fish populations, Model studies.*

FILLINGHAM, J.H. and BOOTSMA, H.A., School of Freshwater Sciences, Uiversity of Wisconsin-Milwaukee, 600 E Greenfield Ave., Milwaukee, WI, 53204. **Modeling Carbon and Phosphorus Cycles in the Nearshore Zone of Lake Michigan.**

Observations of surface water carbon dioxide partial pressure collected at a nearshore monitoring station in Lake Michigan indicate that dissolved $CO_2$ is regularly below saturation during the summer. This suggests that the summertime, Lake Michigan nearshore zone is generally autotrophic. The monitoring station is located in 10m of water north of Milwaukee, WI and has a rocky bottom which supports a standing quagga mussel density of 5500 mussels per square meter. Mussel grazing and particulate nutrient recycling results in the nearshore accumulation of *Cladophora* algae in the summer to nuisance levels. The net influence of mussel grazing, excretion, and respiration and *Cladophora* photosynthesis, respiration and biomass loss due to sloughing on nearshore carbon and phosphorus cycles are investigated at daily and monthly time scales using an ecosystem model for the nearshore of Lake Michigan. Empirical data collected at the nearshore monitoring station during summer 2013 are used to validate model output. Conclusions are drawn on the net influence of nearshore quagga mussels on Lake Michigan carbon and phosphorus cycles. *Keywords: Model studies, Quagga mussels, Phosphorus, Cladophora, Carbon.*

FISK, A.T.[1], MEADOWS, G.A.[2], HEATH, D.D.[1], and SHUCHMAN, R.A.[3], [1]University of Windsoor, 1Great Lakes Institute for Environmental Research, Windsor, ON; [2]Michigan Technological University, Great Lakes Research Center, Houghton, MI; [3]Michigan Technological University, Michigan Tech Research Institute, Ann Arbor, MI. **Concept and Need for a Great Lakes Observatory Network.**

The Great Lakes lack a systematic, coordinated, and sustainable network for monitoring and quantifying physical processes, water chemistry and biodiversity despite their considerable ecologic, social, and economic value. Absence of an observing network creates several problems. First, the Great Lakes are subject to numerous stressors that directly threaten species biodiversity and ecosystem heath and services. Second, the ability to track and monitor biodiversity and its drivers is crucial to the ability of managers and scientists to forecast and respond to current (e.g., harmful algal blooms) and future (e.g., asian carp) threats to ecosystem health and integrity. Third, Great Lakes-wide policy initiatives involving state, provincial, and federal agencies from both Canada and the U.S. (e.g., the Great Lakes Water Quality Agreement of 2012) are increasingly common, creating a demand for knowledge related to lake conservation and management. We propose to develop a bi-national network of fixed and autonomous platforms to describe the physical and biological complexity of near-

shore and offshore habitats of the Great Lakes. A phased approach will be implemented to assure the deliverance of early and persistent high quality science and to afford continued thoughtful, end-user responsive development of the overall system. *Keywords: Ecosystems, Network, Monitoring, Measuring instruments.*

FITZPATRICK, M.[1], MUNAWAR, M.[1], NIBLOCK, H.[1], BOWEN, K.L.[1], and KLING, H.[2], [1]Fisheries & Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6; [2]Algal Taxonomy & Ecology Inc., Winnipeg, MB, R3T 2X8. **Microbial - Planktonic Food Web of a Eutrophic and Contaminated Ecosystem: Hamilton Harbour, Lake Ontario.**

Hamilton Harbour is degraded ecosystem in western Lake Ontario. Eutrophication due to nutrient enrichment and industrial contamination are among the major stressors. Little is known about the structure and function of microbial and planktonic communities in the harbour however such data are essential for a holistic assessment of ecosystem health. Fisheries & Oceans Canada organized a multi-year research and monitoring program beginning in 2002 in order to examine the ecology and dynamics of the pelagic food web. Parameters included bacteria, picoplankton, phytoplankton, nanoflagellates, ciliates and zooplankton. In addition, radioisotope experiments were conducted to estimate primary productivity and bacterial growth rates. During the summer of 2004, for instance, we observed high concentrations of total phosphorous (33 µg/l) as well as chlorophyll a (19.2 µg/l). Similarly, we observed high concentrations of phytoplankton (3.6 g/m3), zooplankton (2.3 g/m3) and microbial loop (0.7 g/m3) indicating an excess of autochthonous (phytoplankton) production. In this presentation, we will examine the transfer of autochthonous energy through the microbial - planktonic food web and consider the potential implications for fisheries which are dependent on the trophic transfer of various sources of energy. *Keywords: Algae, Plankton, Carbon, Phosphorus, Remediation.*

FLYNN, A.M., REDDER, T.M., SCHLEA, D.A., and DEPINTO, J.V., LimnoTech, 501 Avis Drive, Ann Arbor, MI, 48108. **Application of an Enhanced, Fine-Scale SWAT Model to Target Land Management Practices for Maximizing Pollutant Load Reductions in the Tiffin River Watershed.**

The SWAT model has gained widespread use in the Great Lakes region for simulating the delivery of water, sediment, and nutrients from agriculturally-dominated landscapes. Limitations of previous SWAT applications in the region and the Western Lake Erie Basin in particular include relatively coarse spatial scales and the lack of explicit representation for ephemeral gully (EG) erosion. Previous studies in the Maumee River basin have suggested that EG erosion is likely more important than sheet and rill erosion in removing pollutants from agricultural fields in certain regions within the basin. These limitations have important implications for generating realistic projections of sediment and nutrient reductions that are likely to occur as a result of land management practices. To address these limitations, an enhanced, fine-scale SWAT model has been developed for the Tiffin River watershed, a 778 square mile subbasin located within the Maumee River basin. The standard SWAT code was enhanced to include the "tillage-induced ephemeral gully erosion model" and calibrated to available daily flow, sediment, and nutrient datasets. The calibrated model was then applied to quantify the relative pollutant load reductions that could be expected from potential management practices, including cover crops and conservation tillage. *Keywords: Watersheds, Model studies, Pollution load.*

FOLLOWES, E.[2], GEE, K.[1], VARGA, S.[2], and HERNANDEZ, P.[2], [1]2284 Nursery Road, Midhurst, ON, L0L 1X0; [2]50 Bloomington Rd, Aurora, ON, L4G 0L8. **Restoration Priorities in the East Holland River Subwatershed.**

The Ministry of Natural Resources is continuing to identify priority areas for restoration/rehabilitation in the Lake Simcoe watershed. Earlier work identified sections of the existing natural heritage systems that do not have natural vegetative cover. Natural heritage systems (NHS) were intersected with the wetland, woodland or a rare vegetation community layers to isolate areas without natural vegetative cover. Areas that are part of a NHS but are not currently vegetated with natural cover could be targeted as a potential restoration sites. This work further prioritizes those potential restoration sites by focusing on stressed subwatersheds, starting with the East Holland. This work has identified the unvegetated streams (riparian areas) as the highest priority with a target of 30m vegetation on either side. Other priority areas are those riparian areas that have some vegetation on one or both sides but do not meet the 30m target; identification of unvegetated areas that would create interior habitat if they were re-vegetated; areas that if re-vegetated would expand on existing small natural heritage features; and lastly, the identification of overland connections that if re-vegetated would allow for wildlife movement between features. This work will help guide stewardship efforts to maximize benefit to the watershed.

FRAKER, M.E.[1], DEVANNA, K.M.[1], PANGLE, K.[2], ZHAO, Y.[3], and LUDSIN, S.A.[1], [1]Ohio State University, Aquatic Ecology Lab, Columbus, OH, 43212; [2]Central Michigan

University, Mt Pleasant, MI, 48859; [3]Ontario Ministry of Natural Resources, Wheatley, ON, N0P 2P0. **Biophysical Drivers of Walleye Recruitment Variation in Lake Erie.**

Walleye (*Sander vitreus*) exhibit highly variable annual recruitment in Lake Erie's western basin. We developed an individual-based, coupled physical-biological model (ICPBM) to explore the role of biophysical processes in generating this variability. Herein, we contrast variation in larval walleye growth and survival rates between years of strong (1996, 2003) and poor (1995, 2013) recruitment (to the age-0 juvenile stage) to help identify biophysical processes that might underlie these differences in recruitment. Initial modeling results indicate that the relative importance of specific drivers varies from year to year. Our modeling also showed that 1) advection of larvae from their spawning locations into southern, nearshore regions of western Lake Erie, 2) the timing and extent of open-lake plume formation (due to Maumee River), and 3) a proper match between the larval walleye pelagic period and zooplankton availability (in both space and time) can all be important. These findings ultimately point to the value of ICPBMs in helping to understand how biophysical processes can interact to drive recruitment variation. *Keywords: Walleye, Recruitment, Computer models.*

FRANCESCONI, W., SMITH, D.R., and FLANAGAN, D., National Soil Erosion Research Laboratory, 275 S Russell Street, West Lafayette, IN, 47907. **Conservation Practices in APEX: From the Field to the Watershed.**

The St. Joseph River is one of the Conservation Effects Assessment Project (CEAP) benchmark watersheds to conduct research on water quality. The Agricultural Policy/Environmental eXtension (APEX) was used as a modeling approach for quantifying the environmental impacts of conservation practices. The simulation of various single and combined conservation practices was implemented. Seven variables (Surface runoff, Sediments, Total Phosphorus, Soluble Phosphorus, Soluble Nitrogen, Tile Flow, and Soluble Nitrogen in Tile) were compared. Edge-of-field outputs were extrapolated by the areas encompassed by the different conservation practices at the watershed. The percentage reductions in loadings were compared to the baseline scenario. When single conservation practices were implemented, the estimated reductions were 39% for sediment, 7% for TP, and 24% for SN-Tile. In contrast, SP and SN resulted in a -5% and -57% reduction. Negative nutrient load reductions were due to the slightly higher SP and SN loads in no-till, mulch-till, and conservation crop rotation, and their greater extent of incorporation at the watershed. When the conservation practices were combined, the reductions increased for all variables. The cumulative impact of field conservation practices can help improve the water quality concerns at the watershed scale. *Keywords: Nutrients, Conservation, Monitoring, Water quality, Model studies, Agriculture.*

FRIEDLINE, S.N.[1], MCNAUGHT, A.S.[1], JEPLAWY, J.R.[1], and DUNKLEE, L.M.[1], [1]Central Michigan University, 1200 S. Franklin, Mount Pleasant, MI, 48858; [2]Little River Band of Ottawa Indians Natural Resources Department, 159 Brick Yard Rd, Manistee, MI, 49660. **The association between land use and success of wild rice populations in Michigan wetlands.**

Wild rice *(Zizania spp.)* is an annual aquatic grass whose populations have been significantly declining in Michigan wetlands over the past several decades. One possible reason is habitat loss and fragmentation due to agriculture and human development. Such land use changes produce smaller, more isolated populations whose increased likelihood of inbreeding would contribute to a decline in overall population health. In this study, we examined the relationship between land use and the success of wild rice populations in the lower peninsula of Michigan. We sampled 14 wild rice populations from July to October 2013 and measured plant height, leaf length, panicle height, female flower production, and seed bank density. We then used land use/land cover maps in ArcGIS to calculate percent agriculture, percent developed land, percent wetland, percent forest cover, and relative land use richness. It was predicted that greater development and agriculture would be correlated with decreasing wild rice bed size, and that reduced bed size would be inversely related to morphological characteristics, and reproductive success. *Keywords: Wild rice, Land use, Habitat loss.*

FRIES, K.[1], KERKEZ, B.[1], LENTERS, J.D.[2], and GRONEWOLD, A.D.[3], [1]University of Michigan, Civil and Environmental Engineering Department, 2350 Hayward St., 2372 GG Brown, Ann Arbor, Mi, 48109; [2]LimnoTech, 501 Avis Dr, Ann Arbor, MI, 48108; [3]NOAA - Great Lakes Environmental Research Laboratory, 4840 S. State Rd, Ann Arbor, MI, 48108. **A sensor platform for the measurement of evaporation across the Great Lakes.**

The economic impact of recent drops in lake water levels is underscoring the need to urgently improve our understanding of the Great Lakes water budget. Given that lake surface area comprises nearly one third of the entire basin, the component of overlake evaporation presents a major knowledge gap in lake water balance. Our scientific understanding of the effects of evaporation on water levels is presently impeded by very limited evaporation data. Present measurement methods, such as eddy covariance, do not readily lend themselves to offshore measurements. We present a new sensor architecture, which can be deployed on

buoys and drifters to provide real-time measurements of evaporation across the Great Lakes. Our system is comprised of a hierarchy of low-power and cost-effective sensor nodes, which carry out on-board computations to estimate evaporation. An ultra-low power microcontroller front-end samples a suite of sensors to compute evaporation based on an energy budget and Bowen ratio approach. The readings are then transmitted in-real time for scientific analysis and forecasting. The results of this study are expected to form an underpinning for ongoing efforts to deploy an evaporation measurement network across the entire Great Lakes. *Keywords: Sensors, Evaporation, Real-time instrumentation.*

FRIGAULT, J.[1], ALEXANDER, K.[1], PEACH, G.[1], JONES, F.C.[2], and NICOL, M.[3], [1]Lake Huron Centre for Coastal Conservation, 74 Hamilton Street, Goderich, ON, N7A 1P9; [2]Ontario Ministry of the Environment, Environmental Monitoring and Reporting Branch, Dorset Environme, 1026 Bellwood Acres Road, Box 39, Dorset, ON, P0A 1E0; [3]Saugeen Valley Conservation Authority, 1078 Bruce Road 12, Box 150, Formosa, ON, N0G 1W0.
**Spatial and Temporal Variation in Macroinvertebrate Community Composition in the Nearshore Zone along the Eastern Shoreline of Lake Huron.**

Despite the increase in literature describing macroinvertebrate communities in the nearshore zone, there is little literature describing the composition of benthos living at the water's edge (Barton & Griffiths, 1984). The nearshore zone can offer a great deal of information about the ecosystem health because shallow water supports more diverse aggregations of organisms (Barton, D.R., 2004). To examine the community composition of the nearshore zone, sampling using the Ontario Benthic Biomonitoring Network protocols occurred from August-October 2013 along the eastern shoreline of Lake Huron. Additionally, it was recorded how the composition varied spatially, temporally, and among habitat types at the ten sites. In total, 54 distinct taxa were identified. The most dominant taxa at 9 sites were Caenidae, Chironomidae, and Amphipoda. The community composition did vary temporally and by habitat type determined by a principal coordinate analysis with 69% and at least 70% of variation explained within the first two axes, respectively. Habitat types described by the analysis included sandy beaches with a dune system, coastal wetlands, cobble beaches, and protected sites. The differences are most likely due to mesohabitats, emergence patterns (Marshall, 2006), wave action, and spring and winter storms (Metzler & Sager, 1986). *Keywords: Benthos, OBBN, Lake Huron, Species composition.*

FRY, L.M.[1], ANDERSON, E.J.[2], KRAMER, E.L.[1], and RITZENTHALER, A.A.[1], [1]Cooperative Institute for Limnology and Ecosystems Research, 4840 S State Rd, Ann Arbor, MI, 48108; [2]NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Rd, Ann Arbor, MI, 48108. **Linking Hydrological and Hydrodynamics Models to Determine the Impacts of Rivers on Beach Water Quality.**

For swimming beaches near river mouths, river bacterial loads can be a driver of beach water quality. While there is clearly a link between stormwater runoff and beach water quality, the quantification of the contribution of river loadings to observed nearshore bacterial concentrations is complicated due to multiple processes that drive bacterial concentrations in rivers as well as those processes affecting the fate and transport of bacteria upon exiting the rivers. To better quantify potential impacts of rivers on beach water quality, we developed a linked hydrological-hydrodynamics water quality model that simulates accumulation and washoff of bacteria from the landscape, and then predicts the fate and transport of washed off bacteria from the watershed outlet to nearshore zones. The model incorporates a lumped parameter hydrological model, providing runoff and effective precipitation to drive bacterial washoff from the watershed. Washed off bacteria are then input to a 3D particle model in which bacteria are transported via currents produced by the Finite Volume Coastal Ocean Model within GLERL's Huron to Erie Connecting Waterways Forecasting System. We will present results from an application of this modeling system to evaluate the contribution of the Clinton River to Lake St. Clair beach water quality observations. *Keywords: Pollution load, Water quality, Hydrodynamic model.*

FUENTES, L.[1], BOWERMAN, W.W.[1], CHAO, W.Y.[2], and BRIDGES, W.C.[3], [1]1426 Animal Sci/Ag Engineering Bldg #142, University of Maryland, College Park, MD, 20742; [2]261 Lehotsky Hall, Clemson University, Clemson, SC, 29634; [3]O-110 Martin Hall, Clemson University, Clemson, SC, 29634. **Examining Trends of Methylmercury in Michigan Using Nestling Bald Eagle Feathers.**

Methylmercury (MeHg) contamination has impaired the recreational, economic, and nutritional benefits of freshwater resources. Eighty percent of national fish advisories are attributed to mercury (Hg). The bald eagle has been proposed as an indicator of contaminants for the aquatic food chain. Analyzed feather samples from nestlings throughout Michigan provide information about spatial and temporal trends of Hg. Time periods were 1986-1993 (T1), 1999-2003 (T2), 2004-2008 (T3), and 2009-2012 (T4). A total of 1,270 samples were analyzed for Hg. Statewide Hg concentrations were highest during T1 and decreased until the end of T3. There was a small but significant increase in Hg during T4. Geometric

means were 7.62, 3.26, 0.79, and 1.49 mg/kg for T1-T4, respectively. Inland regions had significantly higher Hg concentrations compared to Great Lakes shorelines. Localized observations showed areas of high Hg concentrations along the Lake Superior shoreline of the Upper Peninsula. These data provide managers with information to identify areas that may be of concern due to localized increases in Hg concentrations, and/or having consistently high levels which may translate into risk of nearby fisheries and water resources. Likewise, Hg levels in feathers can provide a measure of remediation efforts at contaminated sites. *Keywords: Methylmercury, Biomonitoring, Bioindicators.*

FUSARO, A.J., DAVIDSON, A.D., SPERONE, F.G., and KASHIAN, D.R., Wayne State University, Department of Biological Sciences, 5047 Gullen Mall, Detroit, MI, 48202. **Creation of a Cumulative Risk Map for Potential Great Lakes Invaders.**

A thorough understanding of potential aquatic nonindigenous species is necessary to provide a complete assessment of risks, which then facilitates successful active monitoring and prevention activities. However, species- and pathway-specific information is often limited or disconnected. To address this need, we integrated assessments of 67 species' potential for introduction, establishment, and impact with georeferenced vector intensity to develop a cumulative risk map for waters in and around the state of Michigan, including western Lake Erie. This project was unique in that it evaluated all taxa using the same risk assessment tool, regardless of taxonomic group or introduction vector. Furthermore, it considered species introduction through six primary vectors, represented by 12 categories of activity, and species' potential for both environmental and socioeconomic impacts. The resulting maps displayed per-vector and overall risk of invasion weighted per grid cell from low to high risk. These maps will be used to better guide managers in monitoring program prioritization in light of limited budgets. *Keywords: Invasive species, Mapping, Risk assessment.*

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GAWDE, R.K.[1], AUER, M.T.[2], DIJKSTRA, M.L.[1], and AUER, N.A.[2], [1]Department of Civil & Environmental Engineering, Michigan Technological University, 1400 Townsend Drive, Houghton, MI, 49931; [2]Great Lakes Research Center, Michigan Technological University, 1400 Townsend Drive, Houghton, MI, 49931. **Hydrodynamics and Thermal Regime in Lake Superior: Impacts of an Episodic Climate Anomaly.**

In recent years, 3D hydrodynamic models have been widely applied in a predictive capacity to all the Great Lakes to study ecosystem response to long-term climate change. But, an alternative aspect of climate change, observed as intermittent climatic anomalies, has not received equal interest. An isolated, positive anomaly observed in local air temperature measurements in March 2012 presents a unique opportunity to study the latter in Lake Superior's ecosystem. Here, a 3D hydrodynamic model, Environmental Fluids Dynamics Code (EFDC), is applied for two consecutive summers, one preceded by the spring anomaly (2012) and the second preceded by average spring air temperatures (2011), to analyze the impact of this climatic anomaly on the thermal regime of the lake. This modeling effort is supported by a rich, comprehensive dataset of surface water temperatures and vertical temperature profiles measured during the April to September period of 2011 and 2012. Impacts of the temperature anomaly were observed along temporal and spatial scales; e.g. the 6°C increase in lake-wide surface water temperatures at the start of summer 2012 as compared to 2011 as well as on the physical processes; e.g. an early onset of thermal stratification (4 weeks in advance) in 2012. These shifts in thermal regimes will in turn affect ecological processes. *Keywords: Ecosystem modeling, Hydrodynamics, Climate change, Thermal regime, Lake Superior.*

GAWOR, A.[1], DRYFHOUT-CLARK, H.G.[2], HUNG, H.[1], ALEXANDROU, N.[1], BACKUS, S.M.[3], BRICE, K.[1], DOVE, A.[3], HITES, R.[4], NETTESHEIM, T.[5], SALAMOVA, A.[4], SU, Y.[1], and VENIER, M.[4], [1]Environment Canada, 4905 Dufferin Street, Toronto, ON, M3H 5T4, Canada; [2]Environment Canada, 6248 Eighth Line, Egbert, ON, L0L 1N0, Canada; [3]Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6; [4]Indiana University, 702 N. Walnut Grove Ave., Bloomington, IN, 47405; [5]U.S. Environmental Protection Agency, 77 West Jackson, Chicago, IL, 60604. **Temporal and Spatial Trends of Atmospheric Deposition of Priority Pollutants to the Great Lakes (1990-2010).**

Monitoring of priority pollutants in the Great Lakes was initiated in 1990 as a Canada/US collaboration to assess temporal and spatial trends in pollutant concentrations and deposition to the Great Lakes. Annual loading estimates (1990-2010) are calculated as the sum of wet deposition, particle dry deposition, and air-water gas absorption and subtracting volatilization from the lakes. Generally, pollutants' loadings to the lake have been declining. This decline was most significant in the early 1990s. For most of the legacy pesticides, namely chlordanes and DDT and its metabolites, loading estimates are quite small and were tending towards air-water equilibrium; and in some cases were dominated by volatilization. α-Endosulfan and γ-HCH, which were last to be restricted among the target chemicals, still show apparent seasonality. Wet deposition fluxes were consistently low, generally less than 1 ng/m$^2$/day (annually averaged) since 2006. PCB fluxes were small, with concentrations approaching blank levels in precipitation. PAHs were dominant in wet and dry depositions with yearly variability. Trace metal loadings are reported for Lakes Huron and Ontario only, with lead fluxes decreasing, selenium's dry deposition fluxes increasing, and arsenic and cadmium's fluxes variable from year to year. *Keywords: Deposition, Atmosphere-lake interaction, Toxic substances.*

GEBREMARIAM, S.Y.[1], MARTIN, J.F.[1], and LUDSIN, S.A.[2], [1]Food, Agricultural and Biological Engineering, 590 Woody Hayes Dr., Columbus, OH, 43210; [2]Department of Evolution, Ecology and Organismal Biology, 1314 Kinnear Road, Columbus, OH, 43212. **The Dynamics of Nutrient Loss from the Maumee River Basin in Response to Hydroclimatic Shifts in the Future.**

Lake Erie has been experiencing extensive cyanobacteria blooms during recent years, which have been linked to dissolved reactive phosphorus (DRP) inputs from the Maumee River. As to whether continued changes in the hydro-climatic regime, owing to anthropogenic forcing, will exacerbate or mitigate this water quality problem in Lake Erie remains unknown. Herein, we used a Soil and Water Assessment Tool (SWAT) hydrology model customized for the Maumee River watershed to compute expected Maumee River discharge and DRP loads from 1950 through 2100. These future projections were computed, using output from 36 different climate models under two IPCC scenarios (RCP 8.5 and RCP 2.6, which respectively represent the status quo and strong international action to limit emissions). We then used a statistical model to generate an index of peak cyanobacteria intensity for each year. While both IPCC scenarios predicted changes in precipitation and temperature, the RCP 8.5 scenario predicted wetter conditions during spring and warmer temperatures during winter and summer throughout the 21st century. In turn, these changes led to significant shifts in spring flow regimes that were accompanied by increased DRP inputs and increased cyanobacteria blooms in Lake Erie. Ultimately, our findings point to the need to adopt land use and crop management *Keywords: Climate change, Nutrients, Harmful algal blooms.*

GEORGE, E.M.[1], LEVINE, M.[2], CRABTREE, D.L.[2], CONNERTON, M.J.[3], JOHNSON, J.H.[4], and RUDSTAM, L.G.[1], [1]Cornell University, Department of Natural Resources, Ithaca, NY, 14853; [2]The Nature Conservancy, 269 Ouderkirk Road, Pulaski, NY, 13142; [3]NY Department of Environmental Conservation, 541 E. Broadway, Cape Vincent, NY, 13618;

[4]USGS Tunison Aquatic Science Laboratory, 3075 Gracie Rd., Cortland, NY, 13045. **Evidence of Cisco Spawning in Chaumont Bay, Lake Ontario.**

Cisco *Coregonus artedii* are an important prey fish for many Great Lakes predators, including lake trout *Salvelinus namaycush*. Their numbers have declined drastically in the last century due to the impacts of invasive species such as sea lamprey *Petromyzon marinus* and alewife *Alosa pseudoharangus*, overfishing, and habitat degradation. Chaumont Bay, New York contains one of the last remaining spawning populations of cisco in Lake Ontario. In November and December of 2013 we attempted to identify the spawning site in Chaumont Bay using radio telemetry. 25 fish were tagged with radio transmitters and tracked through the bay. Samples of the spawning population taken for artificial spawning were collected for aging and biometrics. Years with successful reproduction as evidenced by surviving adults will be correlated with winter and spring weather in those years. Future work on this project includes location and genetic identification of cisco eggs and hatched larvae, investigation into the possible predation on larvae by invasive alewife, and modeling of other potential spawning sites in Chaumont Bay. *Keywords: Fish, Fish tagging, Lake Ontario.*

GERALDI, J.R. and EIMERS, M.C., Trent University, 1600 West Bank Drive, Peterborough, ON. **Nutrient removal efficiency of an urban stormwater pond in Peterborough, ON.**

Stormwater ponds (SWPs) are a common feature in new urban developments where they are designed to minimize runoff peaks from impervious surfaces. SWPs can be efficient at retaining particle-bound nutrients like phosphorus (P). Nitrogen (N) may not be as well retained in SWPs, because N in urban runoff tends to be present in the dissolved form (Rosenzweig et al., 2011). Few studies have examined the year-round retention efficiency of SWPs. In order to contrast seasonal P and N retention efficiency, sampling was conducted at an industrial/residential SWP in Peterborough, ON between October 2012-2013, and high and low flow events were targeted in each season. The majority of P in the inflows to the pond was dissolved (18-100%, avg. 66%), and P retention in the pond was relatively constant between high and low flow events (26-29%) and amongst seasons. The majority of total N was present as (dissolved) nitrate (5-98%, avg. 62%). NO3-N retention in the pond was greater than P, and there was more seasonal variation in N retention, with maximum retention during low flow/summer events (48%) and lowest retention in high flow winter/spring events (23%). These data suggest that pond vegetation were responsible for relatively high NO3-N retention in the summer/low flow season and that vegetation in this SWP are more limited by N than by P. *Keywords: Urban, Stormwater ponds, Nutrients.*

GERLOFSMA, J. and BAILEY, S.A., Fisheries and Oceans Canada, 867 Lakeshore Rd., Burlington, ON, ON, L7R 4A6. **Assessment of plankton density in ballast water samples using a High Resolution Laser Optical Plankton Counter and FlowCAM.**

Ballast water is a major vector for introducing aquatic invasive species into the Laurentian Great Lakes. Regulations introduced in 2006 by Transport Canada (TC) require that vessels entering Canadian waters exchange and/or flush their ballast to ensure a final density of <10 viable organisms per cubic meter for plankton ≥ 50 um. Traditional taxonomic enumeration methods can take days to process and typically do not incorporate a reliable measure of viability. Fisheries and Oceans Canada, in partnership with TC, has purchased a high resolution Laser Optical Plankton Counter (HR-LOPC) and a FlowCAM® with the aim to develop reliable and accurate protocols for ballast water inspection. The HR-LOPC has the capability of acquiring rapid counts of the number of particles in a large volume sample. The FlowCAM, an imaging flow cytometer, can generate quality images of particles in a small volume sample, allowing the user to assess the composition of particles in a sample. Combining these two tools could allow for rapid enumeration and identification of particles in ballast water samples. Here, we present data from laboratory tests evaluating the accuracy, precision and reliability of these instruments for enumeration of plankton greater than 50 um in ballast water and natural water samples. *Keywords: Ballast, Invasive species, Plankton.*

GERTZEN, E.L. and DOKA, S.E., Fisheries and Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **The influence of dissolved oxygen and temperature on fish habitat in Hamilton Harbour.**

Dissolved oxygen and temperature are two vital components of fish habitat. They influence community structure and the physiology, behaviour and survival of fishes. Hamilton Harbour, an embayment at the western end of Lake Ontario that is designated as an Area of Concern under the Great Lakes Water Quality Agreement, is a highly eutrophic system that experiences seasonal hypolimnetic hypoxia. We modelled the extent to which this hypoxia may influence fish habitat in the harbour. Using a literature review and clustering techniques, we divided the Hamilton Harbour fish community into dissolved oxygen tolerance guilds. Using long-term temperature and dissolved oxygen monitoring data from several locations across the harbour, we developed empirical models of the structure of temperature and dissolved oxygen habitat in the harbour. We incorporated these as habitat layers into community-wide fish habitat models and assessed the suitability, or quality, of fish habitat in Hamilton Harbour. The results feed into the evaluation of fish habitat targets under Hamilton Harbour's Remedial Action Plan. *Keywords: Hamilton Harbour, Oxygen, Habitats.*

GEWURTZ, S.B.[1], BHAVSAR, S.P.[2], PETRO, S.[2], MAHON, C.G.[2], ZHAO, X.[2], MORSE, D.[2], REINER, E.J.[2], TITTLEMIER, S.A.[3], BRAEKEVELT, E.[3], and DROUILLARD, K.G.[1], [1]University of Windsor, Windsor, ON; [2]Ontario Ministry of the Environment, Toronto, ON; [3]Health Canada, Ottawa, ON. **High Levels of Perfluoroalkyl Acids in Sport Fish Species Downstream of a Firefighting Training Facility at Hamilton International Airport, Ontario, Canada.**

A recent study reported elevated concentrations of perfluorooctane sulfonic acid (PFOS) and other perfluoroalkyl acids (PFAAs) in surface water, snapping turtles, and amphipods in Lake Niapenco, downstream of Hamilton Airport, Ontario, Canada. Here, our goals were to 1) determine the extent of PFAA in fish collected downstream of the airport, 2) explore if the airport could be a potential source, and 3) compare fish PFOS levels to advisory benchmarks. The PFOS levels in several sport fish collected from the three locations closest to the airport (<40 km) were among the highest previously published in the peer-reviewed literature and also tended to exceed consumption benchmarks. In contrast, PFOS concentrations in the two most downstream locations (>70 km) were comparable to or below the average concentrations in fish as observed in the literature and were generally below the benchmarks. PFOS-based aqueous film-forming foam (AFFF) was used at a firefighting training facility at the airport in the 1980s to mid-1990s. Taken together, our results provide evidence that the historical use of AFFF at the airport has resulted in fish PFOS concentrations that exceed the 95th percentile concentration of values reported in the literature to date. *Keywords: Fish, Perfluorooctane sulfonate, Human health.*

GHANEEIZAD, S.[1], ATKINSON, J.F.[1], SCOFIELD, A.E.[2], WATKINS, J.M.[2], RUDSTAM, L.G.[2], and FENG, Y.[1], [1]Department of Civil, Structural, and Environmental Engineering, University at Buffalo, Buffalo, NY, 14260; [2]Department of Natural Resources, Cornell University, Ithaca, NY, 14850. **Thermocline modeling for the deep chlorophyll layer in Lake Ontario.**

The presence of a sub-surface chlorophyll maximum is a common feature of Lake Ontario during the stratification period. This deep chlorophyll layer (DCL) occurs in the region below the thermocline, or more specifically below the upper mixed layer depth. This study was conducted to study the distribution of the thermocline depth in Lake Ontario and its fluctuations over time as a critical step in predicting the formation and location of the DCL. The thermocline predictions were extracted from modeling results for 2008 and 2013 using POMGL2007, and are compared with extensive temperature profile measurements obtained in April, May, July, August, and September. Model predictions agree well with the measurements in the deeper water regions, but results are poorer in shallower, nearshore regions. Distributions of the thermocline depth also show typical domed or capped behavior under certain conditions. This comparison confirms the ability of the POMGL as a tool to predict the thermocline depth, which is an important component in predicting formation of the DCL. *Keywords: Hydrodynamic model, Deep Chlorophyll Layer, Lake Ontario, Thermocline Modeling.*

GIBBONS, K.J. and BRIDGEMAN, T.B., University of Toledo, 2801 W. Bancroft, Toledo, OH, 43606. **Effect of weather on vertical distribution of algal groups in the western Lake Erie.**

Harmful algal blooms (HABs) are an increasing problem in the Great Lakes, especially in Lake Erie. During HABs western Lake Erie can experience high concentrations of toxins, reduction in water quality, and impairment of recreational use. Estimates of HABs that depend on surface measurements can be problematic due to changes in vertical distribution of cyanobacteria, which may vary with wind speed and diurnal changes in the buoyancy of cyanobacterial colonies. A fluoroprobe was used to profile the vertical distribution of phytoplankton in western Lake Erie on low-wind days in 2009, 2010, and 2012. We examined the vertical distribution of Cyanobacteria, Bacillariophyta, and Chlorophyta in relation to: time of day, temperature, wind speed, wave height, and site depth. The results indicate that the vertical distribution of algal groups on low-wind days is related to wind speed during the preceding night. When preceding night wind speeds averaged were low, cyanobacteria and green algae exhibited distinct vertical profiles with higher concentration near the surface. Understanding changes in vertical distribution of cyanobacteria in western Lake Erie according to weather, site depth, and time of day may be useful for guiding sampling strategies and for improving the estimation of HAB concentration in the water column. *Keywords: Cyanophyta, Monitoring, Phytoplankton.*

GILBERT, J.M.[1], SLAVIK, E.[2], VIDLER, N.[3], CLOUD, P.[4], ALEXANDER, K.[5], and EADIE, A.[6], [1]Chair, Ontario Phragmites Working Group, 1117 North Rd., RR5, Langton, ON, N0E 1G0; [2]Rondeau Provincial Park, 18050 Rondeau Park Rd., RR1, Morpeth, ON, N0P 1X0; [3], Lambton Shores Phragmites Community Group, 10039 Wedd Rd, Port Franks, ON, N0M 2L0; [4]Band Council Member, Environmental Portfolio, 6247 Indian Lane, Kettle and Stony Point FN, ON, N0N 1J1; [5]Lake Huron Centre for Coastal Conservation, 74 Hamilton St., Goderich, ON, N7A 1P9; [6]Deputy Mayor, Municipality of Kincardine, Kincardine, ON. **Controlling *Phragmites* in Ontario: Challenges, Successes, Next Steps.**

The ability to control large, dense, invasive *Phragmites* cells in Ontario's Great Lakes coastal wetlands remains a challenge. Control options are limited for many sites and non-existent when water is present. There is a dire need to have available, on a restricted basis, effective herbicides approved for overwater and aerial application. Without these options, 1000's of hectares of wetland habitat will be lost due to this aggressive invasive plant. The impact on wetland dependant wildlife, including Species At Risk, has the potential to be cumulatively devastating. Despite these challenges, restoration projects are underway with successful outcomes being accomplished. Four of these projects will be highlighted, Rondeau Provincial Park, Kettle and Stony Point First Nation, Municipality of Kincardine and the Municipality of Lambton Shores. Required initiatives to enable effective, efficient and environmentally responsible control of *Phragmites* throughout Ontario will be presented. *Keywords: Phragmites australis, Restoration, Coastal wetlands.*

GILDOW, M.C.[1], GEBREMARIAM, S.Y.[1], MARTIN, J.F.[1], and LUDSIN, S.A.[2], [1]Food, Agricultural and Biological Engineering, The Ohio State University, Columbus, OH, 43210; [2]Department of Evolution, Ecology and Organismal Biology, The Ohio State University, Columbus, OH, 43210. **Reducing Dissolved Phosphorus in the Maumee River through Implementation of Fertilizer Management Practices.**

Recent studies indicate the intensifying eutrophication of Lake Erie results from increasing inputs of soluble reactive phosphorus (SRP), primarily from agricultural runoff from the Maumee and Sandusky watersheds. Recent government reports have recommended using agricultural best management practices (BMPs) to achieve a 41% reduction of springtime SRP loading from the Maumee River in order to reduce the intensity of harmful algal blooms in Lake Erie. Fertilizer placement and improved timing of fertilizer application are two BMPs with a high potential of SRP reduction that have not been previously examined on a watershed-scale in Ohio. Quantification of SRP reduction using fertilizer placement and improved timing throughout the Maumee watershed can be accomplished using the physically-based Soil and Water Assessment Tool (SWAT) modeling program to compare SRP output with a baseline model. In SWAT, implementation of these agricultural BMPs is modeled individually and in combination to determine potential SRP reduction. Preliminary modeling indicates that watershed-wide adoption of fertilizer incorporation instead of broadcast application may reduce SRP loading from the Maumee River by as much as 52%. Analysis of these scenarios will provide further guidance on how to reduce SRP inputs to Lake Erie most effectively. *Keywords: SWAT, Model studies, Maumee River, Phosphorus, Watersheds.*

GLASE, J.D., HUTTO, L.B., LAFRANCOIS, B.M., GAFVERT, U.B., and GOSTOMSKI, T.J., National Park Service, 2800 Lake Shore Drive East, Ashland, WI, 54806. **What lies beneath: mapping coastal waters of Great Lakes national parks.**

The National Park Service (NPS) protects diverse coastal environments in Lakes Michigan and Superior. However, little information exists with respect to the bathymetry, geomorphology, or benthic habitat features of these areas. The NPS and partners are developing high resolution benthic habitat maps for six coastal parks in the Great Lakes, using a novel combination of LiDAR, multi-beam sonar, and satellite imagery. To-date, nearly 1,000 $km^2$ of coastal waters have been surveyed within these parks (including critical lake trout spawning reefs in Lake Superior at Isle Royale National Park), and a seamless bathymetric map has been created for Sleeping Bear Dunes National Lakeshore (Lake Michigan). This information is being used to support fisheries management objectives at Isle Royale; restore coastal processes in four national parks; inform coastal research on nuisance algae, invasive species, and avian botulism outbreaks at Sleeping Bear Dunes; and identify and explore underwater cultural resources at parks throughout the Great Lakes. Importantly, this effort provides new opportunities for the NPS to engage with partner agencies and participate more fully in Great Lakes habitat assessment initiatives and coastal management and restoration efforts. *Keywords: Coastal ecosystems, Benthic mapping, Habitats.*

GLYSHAW, P.W.[1], NALEPA, T.F.[4], RISENG, C.M.[1], POTHOVEN, S.A.[3], VANDERPLOEG, H.A.[2], and EATON, L.A.[1], [1]University of Michigan, School of Natural Resources and Environment, 440 Church Street, Ann Arbor, MI, 48109; [2]National Oceanic and Atmospheric Administration, Great Lakes Environmental Research Laboratory, 4840 S. State Road, Ann Arbor, MI, 48108; [3]National Oceanic and Atmospheric Administration, Great Lakes Environmental Research Laboratory, 1431 Beach St., Muskegon, MI, 49441; [4]Graham Environmental Sustainability Institute Water Center, University of Michigan, 625 E. Liberty, Suite 300, Ann Arbor, MI, 48104. **Temporal Trends in Nutritional State and Reproduction of *Dreissena rostiformis bugensis* in Southern Lake Michigan.**

Currently little is known about the nutritional state and spawning patterns of quagga mussels (*Dreissena rostiformis bugensis*) in deep regions of the Great Lakes. Indices of nutritional state and spawning patterns were determined at monthly intervals (April-September) at three established sites along a depth transect (25, 45, and 93 m) in Southern Lake Michigan in 2013 and compared to values at the same depths in 2004 and 2008. We used condition index (CI), a ratio of dry soft tissue weight to internal shell capacity, to assess nutritional state. In 2013 annual mean CI was 56.6, 32.4, and 37.9 at 25, 45, and 93 m, respectively. At 25 m the CI in 2013 was 31% and 24% lower than in 2004 and 2008 respectively, and at 45 m the CI was 47% and 22% lower. CI was not determined at 93 m in 2004 or 2008. In terms of spawning patterns, ripe mussels were found at 25 m in early summer of 2013 but had not yet spawned in September. In 2008 all mussels were mature in early April and began spawning in early September. Reproductive patterns were more variable at 45 m than at 25 m; however, as observed in 2008 spawning began earlier than at 25 m with half or more mussels spent beginning in July. All mussels at 93 m were mature in April; spawning began in August, slightly later than was observed at 45 m but earlier than those at 25 m. *Keywords: Mussels, Lake Michigan, Invasive species.*

GOBIN, J.[1] and DUNLOP, E.S.[2], [1]Trent University, 1600 West Bank Drive, Peterborough, ON, K9J 7B8; [2]Ontario Ministry of Natural Resources, 2140 East Bank Drive, Peterborough, ON, K9J 8N8. **The Effect of Changes in Growth and Recruitment of Lake Huron Lake Whitefish on Life History Traits, Population Dynamics, and Harvest.**

The establishment of several invasive species have altered food webs and resulted in substantial ecosystem change in several of the Great Lakes. Lake whitefish in Lake Huron still support the Great Lakes' largest commercial fishery, but the productivity of these populations has declined. Using data spanning 25 years from the mid-1980s to 2009, we found previously that changes in both density-dependent growth and stock-recruitment relationships for lake whitefish in response to ecosystem changes, have also likely played a role in recent trends. To further explore the extent to which changes in recruitment and growth may have affected lake whitefish life history traits, population dynamics, and fishing yields, we use an individual-based life history model developed for lake whitefish in the southern main basin of Lake Huron. This model includes these density-dependent relationships as ecological feedbacks and tracks traits such as age and size at maturation for all individuals through time. We can therefore alter these relationships in the model and examine how population abundance and the traits of individuals in the population change in response. Fishing with gillnets and trap nets is also simulated in this model, allowing us to evaluate the role that it plays, as well as the potential impact on yields. *Keywords: Life history studies, Lake whitefish, Lake Huron, Population dynamics, Individual-based model.*

GOGINENI, P., JANUSKA, B.M., MINNIEFIELD, C., and SIMOLIUNAS, S., Detroit River Remedial Action Council, 665 W. Warren Avenue, Detroit, MI, 48201. **The Perennial Problem of Phosphorus in Detroit River.**

As per report of August 2013 of International Joint Commission the phosphorus level rises tenfold in the Detroit River from inflow to outflow to Lake Erie, which has large algal blooms. The control of phosphorus from urban areas depends on separation of sewer pipes from rain pipes and building ditches for rainwater. However, Detroit opted fore retention basins to control combined sewer overflows costing billions of bond money. The idea was based on false theory advanced by Detroit consultants and supported by the state of Michigan. The perennial problem of phosphorus in Detroit river can be solved only by separation of sewer pipes from rain pipes and building ditches for rainwater. *Keywords: Lake Erie, Detroit River, Phosphorus.*

GOLNICK, P.C.[1], QIAN, S.S.[1], and RUBERG, S.A.[2], [1]University of Toledo, Toledo, OH, 43606; [2]NOAA Great Lake Environmental Research Lab, Ann Arbor, MI, 48105. **Thermal Threshold of Hypoxia in Western Lake Erie.**

Summer heat waves cause temporary thermal stratification and benthic hypoxia in the western basin of Lake Erie. The degree of hypoxia may be related to how quickly surface water temperature increases during heat waves and the resulting temperature difference between the surface and bottom waters. The effect of heat waves may also vary depending on the temperature of the sediments, early vs. late summer heat waves, and the depth at which 'uncoupling' between surface and bottom waters occurs. We explored patterns in thermal structure and oxygen depletion rates during heat waves using in situ data collected in 2006 and 2013 by HOBO temperature and dissolved oxygen loggers. Piece-wise linear regression models were used to determine oxygen depletion thresholds based on temperature differences for early, mid, and late summer. The surface-bottom temperature difference required for the onset of rapid oxygen depletion in early summer (0.1°C) was significantly less than the temperature difference required in mid (3-4°C) and late summer (0.5-0.6°C). The results have implications for climate change, suggesting that the occurrence of heat waves earlier in the summer will have a proportionately larger affect than heat waves later in the summer. *Keywords: Climate change, Lake Erie, Oxygen.*

GROFF, C.M. and KASTER, J.L., University of Wisconsin-Milwaukee School of Freshwater Sciences, 600 E Greenfield Avenue, Milwaukee, WI, 53204. **Re-colonization of the *Hexa-***

***genia*** **Mayfly to Lower Green Bay, Lake Michigan: Exploring New Methods to Aid in the Revitalization of an Anthropogenically Degraded Freshwater Ecosystem.**

Nutrient loading and excessive industrial effluence over the past century have lead to hypereutrophication and hypoxia in Green Bay, Lake Michigan. This has lead in turn to significant changes in faunal trophic dynamics (Schloesser 2009), including the local extinction of the *Hexagenia* mayfly, which emerged *en masse* annually prior to 1939 (Fremling 1968). Remediation efforts have taken place in Green Bay for four decades, yet *Hexagenia* have not returned. Recent studies at UWM-SFS suggest water quality is now high enough for habitation by *Hexagenia*. Extensive sampling in Green Bay however, revealed much of the substrate to be high water content fluidized gyttja. This poses a problem for *Hexagenia*, who's life cycle depends on maintaining a physically stable burrow. My research focuses on a novel method for firming-up fluidized sediment by utilizing bioturbation of oligochaete worms in both laboratory-based and *in situ* studies (in progress), and on locating substrate patches in Green Bay which may currently be suitable for *Hexagenia* re-colonization. Focusing efforts on returning a healthy *Hexagenia* population to Green Bay could vastly improve faunal trophic structure, aiding to the recovery of fish and wildlife populations and thus to the recovery of the ecosystem at large. *Keywords: Macroinvertebrates, Trophic Dynamics, Green Bay, Benthos.*

GRONEWOLD, A.D.[1] and STEINMAN, A.D.[2], [1]NOAA-GLERL, 4840 South State Road, Ann Arbor, MI, 48103; [2]Annis Water Resources Institute, 740 West Shoreline Drive, Muskegon, MI, 49441. **Common Drivers Behind Long-Term Water Level Variability and Ecosystem Function Along Earth's Longest Freshwater Coast.**

The coastline of the North American Great Lakes covers a distance of roughly 10,000 miles (about 16,000km) and hosts the largest interconnected coastal freshwater ecosystem on Earth. The long-term health of this ecosystem is critically linked not only to annual- and decadal-scale coastal water level variability, but also to regional hydroclimatic drivers behind both ecosystem function and water level change. Abrupt changes in seasonal precipitation and runoff patterns, for example, impact coastal ecosystems through corresponding changes in seasonal water level cycles as well as through changes in the magnitude and timing of tributary flows. These water level fluctuations may be consistent with seasonal trends or diverge from historical cycles, creating disconnects between water levels and the seasonal phenology of organisms. Here, we explore measurements and model simulations of Great Lakes regional hydroclimatic conditions dating back to the early 1900s to better understand drivers of annual and decadal Great Lakes water level variability, and to differentiate ecosystem alterations that are directly caused by hydroclimate variability from those indirectly impacted by propagation of hydroclimate variability through changes in water levels. *Keywords: Hydrologic cycle, Coastal ecosystems, Water level fluctuations.*

GUDIMOV, A., CHEN, J., ARHONDITSIS, G.B., and DITTRICH, M., Department of Physical and Environmental Sciences, University of Toronto - Scarborough, 1265 MIlitary Trail, Toronto, ON, M4L 3T1. **The effect of sediment diagenesis on hypolimnetic oxygen dynamics in Lake Simcoe.**

Sediment diagenesis can be a significant driver of oxygen depletion in lakes and impact hypolimnetic oxygen concentrations. Reactive-transport models represent a convenient framework to study diagenetic processes in time and space, and as such, offer an essential management tool for addressing "what-if?" questions related to the fate and transport of nutrients in the sediments. In this study, our aim was to assess sediment dynamics under conditions of varying organic matter sedimentation and hypolimnetic oxygen levels using a process-based sediment diagenesis model. In particular, our study identifies critical parameters and explores key mechanisms for reproducing vertical profiles of dissolved oxygen and soluble reactive phosphorus in the sediments of Lake Simcoe. We quantify the prevailing pathways of organic matter mineralization and assess the role of sediment oxygen demand in hypolimnetic oxygen depletion. Our model confirms that aerobic mineralization is a major diagenetic process shaping sediment oxygen demand in Lake Simcoe. We also predict a rapid sediment response to the reduction of organic carbon loading, and provide evidence of spatial heterogeneity between Kempenfelt Bay and Main Basin with respect to sediment oxygen demand and phosphorus sediment release in response to varying boundary conditions. *Keywords: Sediment oxygen demand, Lake Simcoe, Modeling, Sediments, Diagenesis, Biogeochemistry.*

GUDIMOV, A.[1], YOUNG, J.D.[2], PALMER, M.E.[2], STAINSBY, E.[2], WINTER, J.G.[2], DITTRICH, M.[1], and ARHONDITSIS, G.B.[1], [1]University of Toronto, Ecological Modelling Laboratory, Toronto, ON, M1C 1A4; [2]Ontario Ministry of the Environment, Toronto, ON. **Eutrophication Risk Assessment and Adaptive Management Implementation in Lake Simcoe.**

Environmental modelling has been an indispensable tool of the Lake Simcoe restoration efforts. A variety of data-oriented and process-based models have been developed to elucidate the contribution of external and internal nutrient loading to ecosystem integrity and to set water quality goals. In this study, we will present (i) a spatially explicit mass-balance total phosphorus model coupled with a structural equation model which was used to deline-

ate the interplay among nutrients, ambient light conditions, phytoplankton, and herbivorous biomass; (ii) a mechanistic sediment diagenesis model which allowed quantifying the internal loading from the phosphorus diffusive fluxes and evaluating the role of sediment oxygen demand in the end-of-summer hypolimnetic oxygen depletion; and (iii) a spatially-distributed phosphorus model updated with process characterizations for submerged aquatic vegetation and dreissenid mussel abundance. We will present the capacity of these modelling constructs to estimate the critical nutrient loads based on acceptable probabilities of compliance with different water quality criteria (chlorophyll a, total phosphorus, dissolved oxygen) and to provide a realistic platform for analysis of scenarios that can be regularly updated and therefore serve as a long-term tool for adaptive management implementation. *Keywords: Integrated modeling, Environmental policy, Eutrophication, Phosphorus, Adaptive management, Ecosystem modeling.*

GUIASU, R.C. and RONAN, M., Environmental and Health Studies Program, Glendon College, York University, Toronto, ON, M4N 3M6. **Are the Control Programs and Propaganda Against the Rusty Crayfish Justified in Ontario?**

*Orconectes rusticus* is the most reviled crayfish in North America, because this species is considered to be invasive in many parts of this continent. We examine the available information about this species, particularly in Ontario, and we argue that caution should be exercised when implementing control programs against this crayfish, given that the exact limits of the native range of this species, as well as its exact means and rate of dispersal are uncertain, and there are also documented concerns about mistaking similar-looking native crayfish for *O. rusticus*. Furthermore, the impact of *O. rusticus* on other crayfish can vary from location to location and is not always negative or easy to predict. Given the nature of the limited available information about the effects of this species in Ontario, we argue that often the anti-rusty crayfish propaganda does not match the scientific facts. By trying to stop or limit the range expansion of this crayfish species, even when this distribution expansion appears to be quite natural, invasion biologists may in fact attempt to artificially keep the ranges of some species and the species compositions of some aquatic ecosystems "frozen" in time and space, which is ultimately both futile and unrealistic. *Keywords: Ontario, Crustaceans, Biodiversity, Biological invasions, Exotic species, Distribution.*

# H

HALL, J.D. and O'CONNOR, K.M., Hamilton Harbour RAP Office, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **Hamilton Harbour Remedial Action Plan Process: Connecting Science to Management Decisions.**

Hamilton Harbour is located at the western end of Lake Ontario and was designated an Area of Concern (AOC) in 1987. The Stakeholder process consistently followed by the Hamilton Harbour Remedial Action Plan (HHRAP) since the mid-1980s has been identified as one of the best methods for integrating science and public input into management decisions. Using examples from the HHRAP, connections between science and remedial actions are examined along with the relationship of science to the public and political decision makers. HHRAP case studies are offered as examples of how planning and management process integrated and used science to define and refine remedial actions including: upgrades to the wastewater treatment plants, defining the Randle Reef Sediment Remediation Project, and the initial design of fish and wildlife habitat restoration projects. Important lessons about communication, timing, and good process will be highlighted. *Keywords: Hamilton Harbour, Policy making, Management.*

HANSEN, T.H., University of Wisconsin-Milwaukee School of Freshwater Sciences, 600 E. Greenfield Ave., Milwaukee, Wi, 53204. **Processing Seven Plus Years of Bathymetry Data.**

This paper describes ongoing work at the School of Freshwater Sciences to collect and analyze bathymetry data which has been continuously collected from the School's R/V Neeskay since 2006. This paper consists of an overview of the following aspects of this work. First, the methods used to collect the data are described. Second, the various visualization techniques are detailed. This includes both real-time self-updating bathymetry charts which approximate the bottom surface topography which updates as the vessel travels, and more elaborate 3D renderings prepared after the fact. Thirdly, the paper gives a overview of the ongoing work to calibrate the data to maximize its accuracy, by ground-truthing with known datums and already calibrated soundings, as well a the use of statistical methods to identify outliers. Finally, an effort to deploy the data collection system used on the R/V Neeskay to other vessels of opportunity will be described. *Keywords: Lake Michigan, Bathymetry, Data acquisition, Sonar, Spatial analysis.*

HARES, C. and LEONARD, J.B.K., Biology Department, Northern Michigan University, Marquette, MI, 49855. **Round Goby Replacing Native Fauna as Main Littoral Prey Item of Burbot in eastern Lake Michigan.**

With the invasion of Lake Michigan by round gobies (*Neogobius melanostomus*), dramatic shifts in the food web supporting large, native predators such as burbot (*Lota lota*) are likely. Burbot diet was analyzed from eastern Lake Michigan using 553 burbot stomach samples collected from 1999-2012. Non-native round gobies replaced sculpins (Cottidae) as the main littoral diet item during the period. Round gobies appeared in the diet in 1999 and became frequent in 2003. Round goby relative contribution to burbot diet, based on abundance, increased from 1% (± 1.05) in 1999 to 64% (± 4.94) in 2012 with abundance increasing from 0.02 (± 0.02) to 2.8 (± 0.35) goby/stomach in 2012. Conversely, cottid sculpin contribution to burbot diet decreased from 32% (± 3.49) in 1999 to 14% (± 3.47) in 2012 and abundance decreased from 2.36 (± 0.34) to 0.74 (± 0.20) goby/stomach in 2012. This shift in diet is coincident with a decrease in burbot relative abundance in the samples with a decrease in catch per effort from 1999 (4.73 burbot / standard gill net) (± 0.64) to 2012 (2.12 burbot/standard gill net) (± 0.45), mirroring declining burbot populations in Lake Superior. These data help define the striking food web shift that has taken place in Lake Michigan since 2000 and highlight its impact on native predator ecology. *Keywords: Fish diets, Round goby, Food chains.*

HE, J.X.[1], BENCE, J.R.[2], MADENJIAN, C.P.[3], POTHOVEN, S.A.[4], DOBIESZ, N.E.[2], RILEY, S.C.[3], FIELDER, D.G.[1], JOHNSON, J.E.[1], EBENER, M.P.[5], COTTRILL, A.R.[6], MOHR, L.C.[6], and KOPROSKI, S.[7], [1]Michigan DNR Lake Huron Research Station, 160 East Fletcher Street, Alpena, MI, 49707; [2]Michigan State University, 13 Natural Resources Building, East Lansing, MI, 48824; [3]USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105; [4]NOAA Great Lakes Environmental Research Laboratory, 1431 Beach Street, Muskegon, MI, 49441; [5]Chippewa Ottawa Resource Authority, 179 West Three Mile Road, Sault Ste. Marie, MI, 49783; [6]Ontario Ministry of Natural Resources, 1450 East 7th Avenue, Owen Sound, ON, N4K 2Z1; [7]USFWS Alpena Fish and Wildlife Conservation Office, 480 West Fletcher Street, Alpena, MI, 49707. **Using a System of Time-varying Models to Quantify Piscivory Patterns During the Rapid Food-web Changes in the Main Basin of Lake Huron.**

We quantified piscivory patterns in the main basin of Lake Huron during 1984-2010 to understand rapid food-web changes in this large lake ecosystem. We used AD Model Builder to link age-structured stock assessment and fish bioenergetics models for lake trout, Chinook salmon, walleye, and lake whitefish. The model system included time-varying growth, length-weight relations, maturity schedules, energy density, and diets. These models reflected the dynamic connections that at different ages and sizes cohort-specific fish activities responded to the year-to-year ecosystem changes. We found that there were major increases in the predator (predation) to prey ratio over time. The increases in predation pressure on alewives and rainbow smelt came with relatively stable piscivore biomass and total predation, and were supported by alternative energy pathways to and changes in the composition of top piscivores. In addition, while the contribution of fish to annual total consumption by lake whitefish was small, recent annual piscivory by lake whitefish was close to and often exceeding fish consumption by the three top piscivores combined, and thus recent total fish consumption was comparable with fish consumption by the three top piscivores in the middle of 1980s. *Keywords: Bioenergetics, Stock assessment, Fish populations, Time-varying models, Lake Huron, Life-history changes.*

HELM, P., SIMS, A., JUST, E., THIBEAU, J., and TONER, D., Ontario Ministry of the Environment, Toronto, ON, M9P 3R7. **Microplastics in Wastewater Effluents and an Urban Stream Entering Lake Ontario.**

Recent findings of microplastics in water and on beaches of the Great Lakes have drawn attention to this emerging issue. Sources of microplastics to surface waters include the breakdown of plastic debris and litter, feedstock polymer pellets, and microbeads in personal care products. Residues from use of personal care products and debris from stormwater washoff enter municipal wastewater treatment plants (WWTP), and a portion of plastic materials are thought to be released in effluents. However, few published studies document the presence and character of plastics in WWTP effluents. We present the results of sampling of effluents from wastewater treatment plants located adjacent to Lake Ontario and in an urban stream. Initial sampling revealed that of the material collected downstream of a WWTP, a large proportion of what visually resembled plastic was found to be cellulosic material after drying, sorting and verification by Fourier Transform Infrared (FTIR) analysis. Synthetic fibers, microbeads, and other plastic debris were present. In addition to the amount and types of plastics found in WWTP effluents and an urban stream, the impacts of methods of collection, sorting and separation protocols on the physical observations and FTIR analysis results will be discussed. *Keywords: Microplastics, Wastewater, Lake Ontario.*

HENSLER, S.R.[1], STRAKOSH, T.R.[2], BOWEN, A.[3], OLDS, C.[3], and STADIG, E.[1], [1]U.S. Fish and Wildlife Service, Alpena FWCO - Waterford Substation, 7806 Gale Rd., Waterford, MI, 48327; [2]U.S. Fish and Wildlife Service, Green Bay FWCO, 2661 Scott Tower Drive, New Franken, WI, 54229; [3]U.S. Fish and Wildlife Service, Alpena FWCO, 480 W. Fletcher Street, Alpena, MI, 49707. **Fine tuning approaches for aquatic invasive species early detection monitoring.**

In response to decades of invasions by non-native species and prompted by Great Lakes Restoration Initiative goals, the U. S. Fish & Wildlife Service (USFWS) is developing and implementing an early detection monitoring program for non-native aquatic species in the Laurentian Great Lakes. The goal of this program is to detect species while they are still rare enough that eradication efforts may be initiated and vectors addressed in time to stop new invasions from occurring. Building on 2013 pilot collections in the Great Lakes and their connecting waters, current focus is on achieving a 95% annual detection rate for species present in Great Lakes waters where new non-native species are likely to first appear. Taxa of primary focus include fishes and benthic invertebrates. Using risk assessments to inform sample site and gear selection, probabilistic study design to choose specific sampling locations to be examined both spatially and temporally, rarefaction to estimate species detection probability, molecular techniques to improve organism detection and identification, and valuable collaboration with partner agencies and institutions, the USFWS early detection monitoring program is designed to be flexible and responsive to invasive species challenges in a changing world. *Keywords: Fish, Biological invasions, Benthos.*

HERBERT, D.M., Cootes to Escarpment EcoPark System, 680 Plains Road West, Burlington, ON, L7T 4H4. **The Cootes to Escarpment EcoPark System: Protecting natural heritage between the Hamilton Harbour and the Niagara Escarpment.**

The Cootes to Escarpment EcoPark System is a collaborative initiative among ten local government and non-profit agencies to protect, connect and restore almost 1,900 hectares of natural lands and open space between Hamilton Harbour and the Niagara Escarpment at the western end of Lake Ontario. This area is high in biodiversity, with more than 1,500 species documented, and is home to more than 50 species at risk. It is the last intact connection between the Niagara Escarpment and Lake Ontario wetlands and important to the health of Hamilton Harbour and Lake Ontario. The environmental significance of the area has been widely recognized, with designations including UNESCO World Biosphere Reserve (Niagara Escarpment), Important Bird Area, Important Amphibian and Reptile Area, Provincially Significant Wetland, Area of Natural and Scientific Interest, and Environ-

mentally Significant Area. However, these natural lands are located within a large and growing urban area and have been fragmented over time by development. Moreover, the lands are owned or managed by several different agencies. The Cootes to Escarpment EcoPark System is a framework for these agencies to work together to effectively manage and reconnect their natural lands, and to provide ecologically-sustainable recreation, education and research opportunities. *Keywords: Hamilton Harbour, Conservation, Urban watersheds.*

HIRIART-BAER, V.P.[1], BOYD, D.[2], LONG, T.L.[2], CHARLTON, M.N.[1], and MILNE, J.E.[1], [1]Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6; [2]Ontario Ministry of the Environment, 125 Resources Road, Toronto, ON, M9P 3V6. **Hamilton Harbour over the last 25 years: insights from a long-term comprehensive water quality monitoring program.**

In this study, we present the long-term water quality record of Hamilton Harbour (HH) focusing on the parameters and seasonal intervals of particular interest to the Remedial Action Plan and the restoration progress. During the summer period, the record showed that TP decreased in the first decade and has remained relatively unchanged since 1998 while an increasing trend in secchi disc depth was observed until 2005 only to be reversed with a decreasing trend since then. On the other hand, no significant changes in chla have been observed since 1987 despite significant changes in TP. Spring conditions have also changed, and higher conductivity and chla have been measured in recent years. Hypoxia in the hypolimnion of HH remains a common occurrence and the increasing trend in hypolimnetic DO ended in 2003. A strong correlation between spring hypolimnetic DOC and DO depletion rates was found suggesting the organic material load to the harbour is an important controlling factor for hypolimnetic hypoxia. Finally, the data suggest that the hypolimnetic accumulation rate of SRP in the summer has increased since 1987. However, only since 2008 has this increase translated into an increasing trend in hypolimnetic SRP concentrations. These data suggest that conditions have recently changed in HH. *Keywords: Water quality, Phosphorus, Productivity.*

HLEVCA, B.[1], WELLS, M.G.[1], COOKE, S.J.[2], VEILLEUX, M.A.N.[2], and MIDWOOD, J.D.[2], [1]University of Toronto Scarborough, Department of Physical and Environmental Sciences, Toronto, ON; [2]Carleton University, Department of Biology and Institute of Environmental Science, Ottawa, ON. **Water temperature variability in Toronto Waterfront embayments.**

Toronto Waterfront embayments experience substantial temperature variability, during the summer months, which influences the distribution of warm water fish. Frequent upwelling events in Lake Ontario drive water temperature variability within the Toronto Harbour, with numerous occasions where benthic temperatures drop by more than 10ºC in less than 5 hours. We present results from a 3 year study detailing water temperature variability and current profiling in Lake Ontario nearshore and in several Toronto Harbour embayments. We will also discuss results from an acoustic fish tracking study discuss the potential coupling between temperature and habitat use by several fish species. Toronto Harbour is a large system (18 $km^2$) on the northern shore of Lake Ontario (surface area 18,960 $km^2$), with a mean depth of 10 m. It consists of a commercial port and several natural and artificial embayments used for recreational purposes. Toronto Harbour is representative of many degraded industrial harbour environments around the Great Lakes, and our study will help guide remediation efforts aimed at improving fish habitat. *Keywords: Water currents, Bottom currents, Fish behavior.*

HO, J.C.[1], MICHALAK, A.M.[2], BRIDGEMAN, T.B.[3], and STUMPF, R.P.[4], [1]Dept. of Civil & Environmental Engineering, Stanford University, 473 Via Ortega, Stanford, CA, 94305; [2]Dept. of Global Ecology, Carnegie Institution for Science, 260 Panama Street, Stanford, CA, 94305; [3]Dept. of Environmental Sciences, University of Toledo, 6200 Bayshore Rd., Oregon, ON, 43616; [4]NOAA National Ocean Service, 1305 East West Highway, Silver Spring, MD, 20910. **Evaluating LANDSAT algorithms for cataloguing historical harmful algal blooms in Lake Erie.**

As harmful algal blooms (HABs) have become increasingly common in Lake Erie, the paucity of data on historical HABs has become a barrier to deeper understanding of the factors controlling bloom occurrence, timing, and extent. Past analyses based on remote sensing data from MODIS and MERIS have been limited to studying the subset of blooms that have occurred since those instruments began collecting data (1999 and 2002, respectively). In contrast, the LANDSAT Thematic Mapper (TM) has been collecting data since 1982 and could therefore potentially be used to create a longer-term record of Lake Erie blooms. In this work, we assess the use of LANDSAT TM for identifying the presence, spatial extent, and timing of HABs. We do this by comparing metrics produced using different existing LANDSAT algorithms with in-situ Microcystis biovolume and remotely-sensed cyanobacteria data for 2002-2011, leveraging the Google Earth Engine platform for data processing. This assessment will improve understanding of the challenges of monitoring freshwater HABs using remote sensing, and shed light on the feasibility of studying historical HABs in Lake Erie using LANDSAT. *Keywords: Harmful algal blooms, Lake Erie, Remote sensing.*

HOLDA, T.J.[1], RUDSTAM, L.G.[1], WATKINS, J.M.[1], RIHA, M.[1], SCOFIELD, A.E.[1], WALSH, M.G.[2], and O'MALLEY, B.P.[1], [1]Cornell Biological Field Station, Department of Natural Resources, Cornell University, 900 Shackelton Point Rd., Bridgeport, NY, 13030; [2]USGS Lake Ontario Biological Station, 17 Lake Street, Oswego, NY, 13126. **Is the mysid vertical distribution affected by deep chlorophyll layer? Testing the vertical distribution model of mysids.**

Mysid "shrimps" (*Mysis diluviana*) are an integral and important part of the food web of the four deep Great Lakes. This species is both a predator on zooplankton and therefore a competitor with planktivorous fish and a prey for the same fish species. Their spatial distributions determine the degree of interactions with both fish and zooplankton. A model based on the response of these mysids to light and temperature gradients in the laboratory accurately predicted observed vertical distributions of mysids in Lake Ontario in the early 2000's (Boscarino et al. 2009a, 2009b). However, the vertical restructuring of Lake Ontario with the strengthening of the deep chlorophyll layer (DCL) may have altered mysid distributions. During 2013, we collected information on the vertical distribution of mysids in the spring, summer and fall using hydroacoustics and vertical net tows. We used these data to test the ability of Boscarino's model to predict observed distributions where a strong DCL was present, and where it was not. The degree to which the DCL influences mysid distributions will impact their roles as predators and as prey and therefore especially in lakes where the DCL is of increasing importance. *Keywords: Distribution patterns, Mysis diluviana, Model testing.*

HOLDEN, J.P.[1], CONNERTON, M.J.[2], and SCHANER, T.[1], [1]Lake Ontario Management Unit, 41 Hatchery Lane, Picton, ON, K0K2T0; [2]Lake Ontario Fisheries Unit, 541 East Broadway, Cape Vincent, NY, 13618. **Changes in mid sud-summer distributions of Rainbow Smelt and Alewife in Lake Ontario.**

The Ontario Ministry of Natural Resources and the New York Department of Environmental Conservation (NYSDEC) jointly conducted an acoustic prey fish survey in Lake Ontario since 1991. The acoustic survey combined with a trawling survey conducted by the U.S. Geological Survey and NYSDEC assesses the status of alewife and rainbow smelt in Lake Ontario. The acoustic survey consists of five north-south, shore to shore transects and a triangle within the eastern basin. The acoustic data is stratified by temperature and in 2 km intervals along the transects. Alewife density is indexed as targets with a target strength > -45dB and occurring above the thermocline. Smelt density is indexed as targets with a target strength > -55dB and occurring below the thermocline. The decline in both smelt and alewife have been documented in these surveys however a whole lake examination of the spatial distribution has not previously been undertaken. Mysis density, wind patterns and thermocline depth are possible predictors of smelt and alewife distribution during midsummer. *Keywords: Acoustics, Lake Ontario, Alewife.*

HOLECK, K.T.[1], RUDSTAM, L.G.[1], LANTRY, J.R.[2], MCCULLOUGH, R.[3], SANDERSON, M.[4], PRINDLE, S.[5], and TROMETER, B.[6], [1]Cornell Biological Field Station, 900 Shackelton Point Rd, Bridgeport, NY, 13030; [2]NYSDEC, Cape Vincent Fisheries Research Station, 541 East Broadway, Cape Vincent, NY, 13618; [3]NYSDEC, Region 6, 317 Washington St, Watertown, NY, 13634; [4]NYSDEC, Region 8, 6274 E Avon-Lima Rd, Avon, NY, 14414; [5]NYSDEC, Region 7, 1285 Fisher Ave, Cortland, NY, 13045; [6]USFWS, Lower Great Lakes Fish & Wildlife Conservation Office, 1101 Casey Rd, Basom, NY, 14013. **Lake Ontario's Nearshore Zooplankton Community: Response to Invasion by Non-native Species and Changes in Lake Productivity.**

We compared lower trophic level parameters from seven nearshore (10-15 m bottom depth) sites along Lake Ontario's south and east shores from 1995 - 2010 to examine spatial and temporal changes in the nearshore zooplankton community. Zooplankton density and biomass declined significantly at sites closest to the St. Lawrence River but not at sites near the mouth of the Niagara River. Declines were most evident in July and October - times of peak *Cercopagis* and *Bythotrephes* biomass. July and October zooplankton density and biomass declined significantly due to declines in bosminids, daphnids, and cyclopoids. There was no trend in either spring TP or seasonal Secchi depth, but summer cholorophyll-*a* increased significantly. Change points were detected in cholorphyll-*a*, and July and October zooplankton density and biomass at times corresponding to the arrival of *Cercopagis* and increase in *Bythotrephes*. Nearshore patterns are similar to published findings for offshore waters. *Keywords: Zooplankton, Invasive species, Lake Ontario, Monitoring.*

HONDORP, D.W., USGS-Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105. **Rethinking Sturgeon Migration: Dispersal Patterns of Lake sturgeon in the Lake Huron-to-Lake Erie Corridor.**

This presentation summarizes recent results for an ongoing project focused on helping fishery managers quantify the spatial extent, population structure, and abundance of the lake sturgeon (*Acipenser fulvescens*) that spawn in the Detroit-St. Clair river system (DSCRS). A key question is whether DSCRS lake sturgeon represent a single population or several semi-isolated demes functioning as a metapopulation. To address this question, lake sturgeon were captured, implanted with acoustic transmitters with a 10-year battery life, and then released back into the environment. Since spring 2012, movements of tagged individual have been tracked on strategically located lines of acoustic receivers. Analysis of tracking data showed that SCRS lake sturgeon have complex migration patterns with some individuals migrating as far 150 km during the period of observation. Movement data to date suggest that DSCRS lake sturgeon function as multiple partially-isolated spawning groups rather than a single population. Surprises revealed by year-round tracking of sturgeon movements included the high prevalence of partial migration, upstream movements to feeding/overwintering grounds, and near complete lack of use of Lake Erie. Fish tracking data also led to the discovery of important sturgeon overwintering habitats in Lake St. Clair. *Keywords: Fish behavior, Lake sturgeon, Detroit River, St. Clair River.*

HONSEY, A.E.[1], BUNNELL, D.B.[2], TROY, C.D.[3], FIELDER, D.G.[4], THOMAS, M.V.[5], LAUER, T.E.[6], KNIGHT, C.T.[7], CHONG, S.[8], and HÖÖK, T.O.[1], [1]Department of Forestry and Natural Resources, Purdue University, 195 Marsteller St., West Lafayette, IN, 47907-2033; [2]USGS Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105-2807; [3]School of Civil Engineering, Purdue University, 550 Stadium Mall Drive, West Lafayette, IN, 47907-2051; [4]Michigan Department of Natural Resources, Alpena Fisheries Research Station, 160 E. Fletcher, Alpena, MI, 49707; [5]Michigan Department of Natural Resources, Lake St. Clair Fisheries Research Station, 33135 South River Road, Harrison Twp, MI, 48045; [6]Department of Biology, Ball State University, 2000 W. University Ave, Muncie, IN, 47306; [7]Fairport Fish Research Station, Ohio Department of Natural Resources, 1190 High St., Fairport Harbor, OH, 44077; [8]Fish and Wildlife Services Branch, Ontario Ministry of Natural Resources, 1235 Queen St. E., Sault Ste. Marie, ON, P6A 2E5. **Recruitment Synchrony of Yellow Perch *Perca flavescens* in the Great Lakes Region, 1966-2008.**

Population-level reproductive success (recruitment) of many fish populations is characterized by high inter-annual variation and related to annual variation in key environmental factors. When such environmental factors are annually correlated across broad spatial scales, spatially separated populations may display recruitment synchrony. We investigated inter-annual (1966-2008) variation in yellow perch *Perca flavescens* recruitment using 16 datasets describing 12 populations in four of the five Laurentian Great Lakes (Erie, Huron, Michigan, and Ontario)and Lake St. Clair. We indexed relative year class strength as the average deviance of catch-curve residuals for each year class across 2-4 years and compared relative year class strength among populations. Results indicate that perch recruitment is synchronized across the region. To investigate potential factors influencing relative year class strength, we related year class strength to regional indices of annual climatic conditions (spring-summer temperature, winter temperature and spring precipitation) using data from 14 weather stations across the Great Lakes region. We found that mean spring-summer temperature is significantly positively related to recruitment synchrony among Great Lakes yellow perch populations. *Keywords: Recruitment, Percids, Fisheries.*

HOOD, J.L.A. and VAN CAPPELLEN, P., University of Waterloo, 200 University Ave W, Waterloo, ON, N2L 3G1. **Landscape controls on Si concentration and the seasonal Si cycle.**

Silicon (Si) is an important nutrient in aquatic environments and is required for diatom frustrule formation. The availability of Si relative to other nutrients, may control the structure and succession of phytoplankton communities, making Si a potential driver of eutrophication. Bedrock type, weathering rates and terrestrial vegetation are factors known to influence dissolved Si (DSi) fluxes at the landscape scale. How these factors, along with anthropogenic influences, affect DSi concentrations and seasonal Si cycling in river systems is largely unknown, however. Using the provincial water quality monitoring network dataset (PWQMN) provided by the Ontario Ministry of Environment (Canada), Satellite data from The Ontario Land Cover Database (OMNR), we tested several factors that may influence the DSi concentration and the annual DSi range (as a proxy for seasonal cycling) for 110 monitoring stations within 63 distinct sub-watersheds for the years 2005 to 2011 in a multivariate analysis. Results suggest that while the number of wetlands within a watershed best relates to the average DSi concentration, the amount of land under agriculture significantly impacts the annual range in DSi. The results indicate that both the timing and the quantity of Si delivered to rivers are influenced by human activity within the watersheds. *Keywords: Biogeochemistry, Eutrophication, Watersheds.*

HORKOVA, K. and KOVAC, V., Comenius University, Faculty of Natural Sciences, Department of Ecology, Mlynska dolina B2, Bratislava, 84215, Slovakia. **Temporal Aspect,**

**Ontogenetic Phenomena and Ecological Factors in the Successful Invasion of Round Goby *Neogobius Melanostomus* in the River Danube (Central Europe).**

It has been found that round goby from freshly invaded areas (invasion front) exhibit different life-history traits (LHT) compared to individuals from longer established areas (core or centre areas). The theory of alternative ontogeny and invasive potential predicts such differences. Nevertheless, it is difficult to distinguish between the effects of ontogenetic phenomena and the effects of particular ecological factors on LHT of populations at various stages of invasion. Thus, we tested the prediction that sub-populations of round goby from two habitats exposed to a different intensity of anthropogenic pressures in the Danube, but at the same stage of invasion, will have significant differences in their reproductive parameters. All four reproductive parameters tested (size of oocytes, absolute number of oocytes, real absolute fecundity and body size at maturity) were found to comply with the prediction. The results suggest that the changes in LHT observed over the progressing invasions of fishes are typical rather than accidental, being related to the stage of invasion and closely associated with ontogenetic phenomena. However, ecological factors also affect this process: if the habitat is exposed to permanent disturbance, the established invasive population will keep the same LHT as at the beginning of invasion. *Keywords: Europe, Life history studies, The Danube River, Round goby, Invasive species.*

HOSSAIN, M.[1] and STEWART, T.J.[2], [1]Ontario Ministry of Natural Resources, Aquatic Research and Development Section, Picton, ON, K0K 2T0; [2]Ontario Ministry of Natural Resources, Lake Ontario Management Unit, Picton, ON, K0K 2T0. **Linear Inverse Modelling: A New Tool To Examine Food Web Scale Questions In The Great Lakes.**

Development of food web models linking changes in Great Lakes water quality, lower trophic levels, invasive species and fisheries can provide mechanistic understanding useful to development of management policy. A very popular approach is the use of ECOPATH with ECOSIM (EwE) software platform which facilitates specification and quantification of mass-balance food web models and simulation. More recently, linear inverse model (LIM) implemented in open source RLanguage has been applied to solve similar food web mass-balance structures but has yet to be applied in Great Lakes investigations. In this paper, we "translate" a published Lake Ontario ECOPATH model into a LIM structure and illustrated its application. We discuss the advantage the LIM approach as complementary to existing EwE model which has the ability to solve multiple mass balances simultaneously and retain solutions, specify and account for uncertainty in model inputs, the ability to statistically examine model parameter interactions, and the ability to formulate and test hypotheses. We also discuss the disadvantage of LIM approach and make suggestions regarding future applications to Great Lakes research and management. *Keywords: Lake Ontario, Ecosystem modeling, Mass balance.*

HOWE, R.W.[1], NIEMI, G.J.[2], WALTON, N.G.[1], GIESE, E.E.G.[1], BRACEY, A.M.[2], BRADY, V.[2], BROWN, T.[2], CIBOROWSKI, J.J.H.[3], DANZ, N.[4], GATHMAN, J.[5], HOST, G.[2], JOHNSON, L.B.[2], KOVALENKO, K.E.[3], and REAVIE, E.D.[2], [1]Cofrin Center for Biodiversity/Department of Natural and Applied Sciences, University of Wisconsin-Green Bay, Green Bay, WI, 54311; [2]Natural Resources Research Institute, University of Minnesota-Duluth, Duluth, MN, 55811; [3]University of Windsor, 401 Sunset Ave., Winsdor, ON, N9B 3P4; [4]Department of Biology, University of Wisconsin-Superior, Superior, WI, 54880; [5]Department of Biology, University of Wisconsin-River Falls, River Falls, WI, 54022. **Measurable Responses of Great Lakes Coastal Wetland Biota to Environmental Stressors.**

The idea that animal and plant species are useful indicators of environmental quality is widely accepted, but the specific environmental stressors to which different species respond are rarely identified. In other words, we don't always know exactly what these species indicate, and even when stress-response relationships are documented, we rarely know how the biotic signal is confounded by biogeography or local ecological circumstances. Recent data from a large scale study of Great Lakes coastal wetlands allows us to quantify stress-response relationships of birds, amphibians, invertebrates, fishes, diatoms, and wetland plants. As expected, different taxa respond to different stressors, and the nature of these responses is not uniform among species within the same taxonomic group. This finding implies that comprehensive environmental indicators based on species richness or related metrics are misleading or, at best, difficult to interpret. We propose an alternative approach that incorporates explicit stressor-response relationships of species or ecological guilds. This maximum likelihood method is flexible and can generate multi-species metrics that incorporate information from a variety of taxonomic groups. *Keywords: Indicators, Monitoring, Wetlands.*

HOWELL, E.T., Environmental Monitroing and Reporting Branch, Ontario Ministry of the Environment, Toronto, ON, M9P 3V6. **Water Quality on the Toronto-Mississauga Waterfront after the July 8, 2013 Deluge.**

The shoreline of Lake Ontario in the Greater Toronto area experienced heavy rainfall on the evening of July 8, 2013 resulting in a surge in runoff. The rain storm impacted water quality in the adjacent lake resulting in strongly elevated levels of suspended solids, phosphorus and fecal pollution indicators. Monitoring on July 9 conducted over the Mississauga-Toronto waterfront, an area strongly affected by the event, indicated that runoff-impacted water extended >3 km into the lake but was heterogeneously distributed through the water column. An appreciable load of phosphorus, the majority of which was bound to particulate material, was delivered to the lake during the event as inferred from the estimated phosphorus content of the water column over the approximately 50 $km^2$ of nearshore surveyed. Nearshore phosphorus supply was likely impacted both by a pulse of sedimentation and more broadly by alongshore transport which was oriented towards the eastward in the immediate aftermath of the storm. *Keywords: Nutrients, Lake Ontario, Urban areas.*

HRYCIK, A.R., SESTERHENN, T.M., and HÖÖK, T.O., Department of Forestry and Natural Resources, Purdue University, 195 Marsteller Street, West Lafayette, IN, 47907. **An eco-genetic model to understand fish movement decisions.**

Influences of environmental conditions on fishes are mediated through behavioral responses (e.g., movement). Thus, anticipating the influences of environmental stressors on fishes is dependent upon accounting for such behavior. Many fish models face the problem of incorporating accurate rules for movement. We explored this problem by integrating movement rules into a 1D individual-based model of yellow perch, *Perca flavescens*, in the central basin of Lake Erie, where temperature, light, oxygen concentration, prey availability, and predation risk may all influence movement. Movement rules were implemented in an eco-genetic framework and were represented as heritable weightings of potential habitat characteristics: temperature, dissolved oxygen, prey density, predator density, and light availability. Simulations were carried out for several generations, with fish that exhibited better growth and survival based on habitat choices able to pass on their movement preference genes to more offspring. Simulations were run with and without hypoxia, and with a wide range of temperature, prey, predator, and light scenarios. Optimal movement strategies shifted with changing environmental conditions, providing insight into the importance of using accurate movement rules in modeling. *Keywords: Hypoxia, Eco-genetic model, Movement rules.*

HU, H.[1], WANG, J.[2], SCHWAB, D.J.[2], BELETSKY, D.[1], LESHKEVICH, G.[2], HAWLEY, N.[2], and CLIDES, A.[2], [1]CILER, The University of Michigan, Ann Arbor, MI, 48108; [2]NOAA/GLERL, Ann Arbor, MI, 48108. **Simulation of ice and circulation in Lake Erie.**

A 2 km Great Lake Ice-circulation Model (GLIM) was implemented in Lake Erie to investigate seasonal variations of ice and circulation under daily and hourly atmospheric forcing. The results show that ice forming and melting are consistent with observations. Ice cover with a maximum of 22,000 $km^2$ occurs in January and February. The ice drifts follow the winds but with a declination. The simulated vertical temperature structures agree with 2004 mooring data. The circulations in winter differ from in summer are due to the changes of the winds and the temperature structure. *Keywords: Ice, Circultion, Lake Erie, Model studies.*

HUTCHINS, R.H.S. and SCHIFF, S.L., Department of earth & Environmental Sciences, University of Waterloo, Waterloo, ON, N2L 3G1. **Cities permanently alter riverine dissolved organic matter quality.**

For the first time in history, the human urban population is greater than that of rural. Urban land use increases loading of inorganic nutrients, sediments, alters hydrology and morphology of rivers, however the impact on riverine dissolved organic matter (DOM) is largely unstudied despite the importance of rivers in the global carbon cycle and the projected increase in urban land-cover in the coming decades. Here, we survey dissolved organic matter in the Grand River watershed, Canada, with predominately agricultural land-cover shifting to more urban downstream, reflecting a similar change in the Earth's human land use. We show a change in DOM character in response to an increase in urban land-cover. Specifically, we find a loss of aromaticity, humicity and molecular size of DOM as the ratio of urban to cropland increases. Simultaneously, the amount of microbially derived, organic nitrogen rich, and δ15N enriched DOM increased with greater urban land use. Furthermore, we find that there is no recovery of DOM character to its prior state downstream of the urban impact. We suggest that these effects of urbanization on the character of riverine DOM will have important implications for global carbon cycling and water use as the urban population is expected to double and the urban land-cover to triple in the next several decades. *Keywords: Dissolved organic matter, Carbon, Grand River.*

HUTCHINSON, N.J.[1], SINCLAIR, D.L.[1], BRETON, H.[2], and HARRISON, J.W.[1], [1]Hutchinson Environmental Sciences Ltd., Suite 202, 501 Krug St., Kitchener, ON, N2B 1L3; [2]Hamilton Conservation Authority, P.O. Box 81067, 838 Mineral Springs Road, Ancaster, ON, L9G 4X1. **Development of an Export Coefficient Model to Assess Management of Urban Stormwater Quality in Spencer Creek, Dundas, ON.**

Phase 1 of the Integrated Subwatershed Study of Lower Spencer Creek identified six pollutants of primary concern and the role of suspended solids in tracing their sources and pathways to the creek. An export coefficient model was developed and validated against long term hydrologic and water quality monitoring at three long-term sites in the watershed, supplemented by three short term sites and event monitoring to document the transition of the watershed from agricultural to urban land uses. Remedial measures were identified for six sources of water quality degradation and their stability and effectiveness assessed for existing conditions and for modelled estimates of creek response to three future scenarios; including naturalization in urban areas, increased irrigation demand and drought and increased storm severity in a changed climate. *Keywords: Urban watersheds, Water quality, Hamilton Harbour.*

# I

IBSEN, M.[1], KUMAR, A.[2], NEUFELD, J.D.[3], and KIRKWOOD, A.E.[1], [1]Faculty of Science, University of Ontario Institute of Technology, 2000 Simcoe St. N., Oshawa, ON, L1H 7K4; [2]Department of Microbiology, University of Manitoba, 414E Buller Building, Winnipeg, MB, R3T 2N2; [3]Dept. of Biology, University of Waterloo, 200 University Ave.W., Waterloo, ON, N2L 3G1. **The Role of *Cladophora glomerata* as a Refuge for Fecal Bacteria and Antibiotic Resistance in an Urbanized Near-shore Zone of Lake Ontario.**

*Cladophora glomerata* is a filamentous macroalga that fouls beaches throughout the lower-Great Lakes. Our study aims to characterize the bacterial communities associated with viable and decaying *C. glomerata* mats up- and down-gradient from a sewage treatment plant. The presence and abundance of antibiotic resistance genes in these communities were also assessed. Samples of lake water and *C. glomerata* mats (free-floating and beached) were taken along the Lake Ontario shoreline in Durham Region, ON (August to September 2013). Bacterial communities from *C. glomerata* mats were assessed using next-generation Illumina sequencing of 16S rRNA, and antibiotic resistance genes were detected by quantitative PCR. We have determined via lab studies that *C. glomerata* exudates can support *E. coli* growth, especially during senescence. Plating water and *C. glomerata* samples on antibiotic growth media showed the prevalence of antibiotic resistance genes to be greater in samples taken down-gradient of the sewage treatment plant. Results from Illumina sequencing and qPCR will also be presented. *Keywords: Antibiotic resistance, Lake Ontario, Bacteria, Cladophora, Human health.*

IRELAND, D.H., Royal Ontario Museum, 100 Queens Park, Toronto, ON, M5S 2C6. **The World's Largest BioBlitz, and telling our environmental stories effectively.**

This presentation will describe two new projects at the Royal Ontario Museum. Both projects rely on partnerships and fill a gap in successful biodiversity conservation, namely: public engagement and support, and effective science communication. The first project, the Ontario BioBlitz Program (www.ontariobioblitz.ca) is the largest of its kind in the world, and has two distinct objectives: 1) document biodiversity in a given area over a set amount of time, and 2) provide a conduit for interested and engaged public citizens to join the effort and become advocates for nature conservation. The Ontario BioBlitz Program is strategically aligned with several local, regional and national conservation organizations. And the Environmental Visual Communication Program (www.eviscomm.ca) is a unique, graduate level learning program that bridges the world of art and science with the goal to produce better, more convincing story-tellers in the environmental sector. The EVC Program is administered by Fleming College and is hosted at the ROM. Students are taught by faculty in videography, conservation photography, social media, professional design techniques, branding and workflow management. Recent EVC students have traveled to Borneo and Guyana to help ROM scientists report back on their work. All EVC students participate in the BioBlitz *Keywords: Participatory science, Conservation, Visual communication, Biodiversity, Education.*

IVAN, L.N.[1], HOFF, M.[2], MASON, D.M.[3], RUTHERFORD, E.S.[3], and ZHANG, H.[1], [1]SNRE-CILER, University of Michigan, Ann Arbor, MI, 48108; [2]US Fish and Wildlife Service, Fisheries Program, Bloomington, MN, 55437; [3]NOAA-GLERL, Ann Arbor, MI, 48108. **Will Asian Carps Successfully Invade and Impact the Saginaw Bay, Lake Huron Food Web?**

Silver (*Hypophthalmichthys molitrix*) and bighead carp (*H. nobilis*) threaten to invade the Great Lakes and impact the food webs and fisheries. To predict the likelihood of establishment, and evaluate the potential impact of Asian carps on important fishes in Saginaw Bay, we developed a spatially-explicit, multispecies, individual-based community model (IBM) of Asian carps and the Saginaw Bay food web. The IBM tracks daily foraging, movement, growth and survival of individual fish including Asian carps, walleye, yellow perch, rainbow smelt, and round goby. The model also tracks biomass dynamics of lower trophic levels (phytoplankton, detritus, zooplankton, *Bythotrephes*, benthos, dreissenids, forage fish). We ran 50-year simulations of Asian carp introduction scenarios including: one-time introductions of each Asian carp species alone or together; and multiple introductions during the first 25 years of a 50-year simulation. For each scenario, we determined the minimum population size required for establishment and, for successful invasion scenarios, determined the impact on fishes and biomass pools. In the future, we will model potential Asian carp impacts on food webs and fisheries in Lake Erie and Lake Michigan. *Keywords: Asian carps, Invasive species, Lake Huron, Fish populations, Model studies, Fisheries.*

IVES, J.T.[1], MARTY, J.[2], KOOPS, M.A.[3], DE LAFONTAINE, Y.[4], and POWER, M.[5], [1]Great Lakes Fishery Commission, 2100 Commonwealth Blvd., Suite 100, Ann Arbor, MI, 48197; [2]WSP Canada Inc., 2611 Queensview Dr., Suite 300, Ottawa, ON, K2B 8K2; [3]Fisheries and Oceans Canada, 867 Lakeshore Rd., Burlington, ON, L7R 4A6; [4]Environment Canada - Centre St. Laurent, 105 McGill St., Montreal, QC, H2Y 2E7; [5]University of Waterloo, 200 University Ave. W., Waterloo, ON, N2L 3G1. **Inter- and Intra-annual Variability in the δ13C and δ15N Isotope Values of *Hemimysis anomala*, the Bloody Red Shrimp.**

Over 180 invasive species have been documented within the Great Lakes basin, yet few temporal studies have been completed to determine how the trophic position of an invader varies within the invaded food web seasonally or inter-annually. To examine temporal variations in the food web niche of the invasive mysid, *Hemimysis anomala*, two sites in the Great Lakes basin were repeatedly sampled for *Hemimysis* and related food web items between May 2009 and January 2012. Stable isotope values obtained from the samples were used to examine temporal variation in the main food sources and trophic position of *Hemimysis*. *Hemimysis* have previously been found to show significant spatial variation in food web niche use in the Great Lakes basin. In this study *Hemimysis* were found to vary seasonally by > 3 ‰ in mean $\delta^{13}C$ and $\delta^{15}N$. Significant correlations were found between *Hemimysis* isotopic values and site characteristics including water temperature and the isotopic values of particulate organic matter (POM). Results of the study imply that temporally limited studies of isotopic niche use by invasive species provide an incomplete "snapshot" of an organism's true position in a food web. *Keywords: Invasive species, Isotope studies, Niches.*

# J

JABBARI SAHEBARI, A.[1], SCALO, C.[2], BOEGMAN, L.[1], and PIOMELLI, U.[2], [1]Queen's University, Civil Engineering, Kingston, ON; [2]Queen's University, Mechanical Engineering,

Kingston, ON. **Large Eddy Simulation of a turbulent oscillating bottom boundary layer.**

This study presents a Large Eddy Simulation (LES) of a fully turbulent oscillating bottom boundary layer (BBL), driven by low speed internal seiching, as found in a medium-sized lake. There are no general solutions for this flow and so the simulations are validated against published velocity and dissipation measurements from acoustic Doppler current profilers (ADCPs) and temperature microstructure. We also compare the results to theoretical solutions from the log-law of the wall for steady unidirectional flow. The velocity and dissipation rates from LES and the observations show better agreement, than the log-law, at the end of the acceleration and beginning of the deceleration phases that are associated with turbulence production. Discrepancies between the simulations and ADCP dissipation measurements are attributed to the uncertainty of isotropy the constants required in computing dissipation from ADCP data using the inertial method. The observed estimates of dissipation are closer to the LES than the log-law in the turbulent phases, during which the turbulence is homogeneous and isotropic. Both measurements and simulations show a phase lag between the current forcing and dissipation. These results have implications for predicting nutrient and sediment dynamics in oscillating lake-type boundary layers. *Keywords: Turbulent kinetic energy dissipation, Oscillating bottom boundary layer, Large Eddy Simulation.*

JACKSON, E.W.[1], O'MALLEY, B.P.[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; [2]USGS Great Lakes Science Center, Lake Ontario Biological Station, 17 Lake Street, Oswego, NY, 13126. **Diel shifts in zooplankton distributions in Lake Ontario 2013: effects of zooplankton on the deep chlorophyll layer.**

The vertical distribution of zooplankton in Lake Ontario is being restructured as a result of increased water clarity, declining epilimnetic nutrient concentrations, and induced vertical migration by predatory cladocerans. As a result, zooplankton grazing and subsequent nutrient regeneration may occur at deeper depths which has the potential to influence the vertical dynamics of primary production. Among the goals of this year's Cooperative Science and Monitoring Initiative (CSMI) was to measure the vertical distribution of primary production and understand how zooplankton affect this distribution. Understanding zooplankton effects require information of their distribution both day and night. We present zooplankton data from depth stratified tows (64 μm epilimnion, metalimnion, hypolimnion) on the diel distribution of zooplankton to estimate grazing and nutrient generation occurring at different depths and magnitudes of the deep chlorophyll layer. *Keywords: Zooplankton, Lake Ontario, Distribution patterns.*

JACOBS, G.R.[1], HUSSEY, A.[2], and FISK, A.T.[2], [1]U.S. Fish and Wildlife Service, Northeast Fishery Center, 227 Washington Ave., PO Box 75, Lamar, PA, 16848; [2]Great Lakes Institute for Environmental Research & Department of Earth and Environmental Sciences, University of Windsor, 401 Sunset Ave, Windsor, ON, N9B 3P4. **Evaluating the effects of ontogeny and ecosystem change on lake sturgeon trophic ecology.**

Since in the 1990s, lake sturgeon have increased in abundance in the lower Niagara River (LNR). Consequent with this increase, invasive species-induced ecosystem change was sweeping the Great Lakes. Archived pectoral spines taken from lake sturgeon captured between 1999 and 2012 and cross-sectioned for age estimation may provide information on how growth and ecosystem change may have affected lake sturgeon during this time period. After age estimation, a drill was used to collect material from three non-overlapping growth band groups from each spine, beginning at the origin (first year of growth). We then used analysis of N and C stable isotope ratios to evaluate two hypotheses: 1) is there an ontogenetic shift in trophic position the life history of lake sturgeon in the LNR, and 2) have invasive-species-mediated ecosystem shifts during the 1990s and 2000s altered the trophic ecology of lake sturgeon in the LNR. To evaluate these hypotheses, we used mixed effects models to test the effects of fish age (ontogenetic effect), year (ecosystem effect), and their interaction, with a random effect of individual fish. Back-estimating the trophic position and carbon sources of each fish in this manner may provide insight into how ecosystem change may have affected lake sturgeon life history in the recent past. *Keywords: Lake sturgeon, Stable isotopes, Lake Ontario.*

JANSSEN, J.[1] and JUDE, D.[2], [1]University of Wisconsin-Milwaukee, School of Freshwater Science, 600 E. Greenfield Rd., Milwaukee, WI, 53204; [2]School of Natural Resources and Environment, University of Michigan, 440 Church St., Ann Arbor, MI, 48114. **Goby Lemonade.**

Two score and eight years ago our Twofathers (Tody and Tanner 1966) brought forth upon the Great Lakes a new ecosystem, conceived in sport fisheries, and dedicated to the proposition that a nuisance (alewife) could be converted into a resource so that the salmon coast and the freshwater coasts should be sport fishery equals. Now we are engaged in a great ecosystem cataclysm, testing whether Great Lakes ecosystems can long endure the new ensemble of invasives. We are met in a great IAGLR conference session on that meltdown, here to determine whether the meltdown generates the final Great Lakes resting place, or is transformed into a new ecosystem vision. It is altogether fitting and proper that we should do this. The world may or may not note what we say here today. But it will if we make the proper management choices and we can turn round gobies from lemons into lemonade, much as our Twofathers rendered alewives into champaign! We here highly resolve that these invaders do not generate meltdown, that the Great Lakes shall have a new birth of fisheries, that fisheries of the people, by the people, and for the people shall not perish from the Great Lakes. *Keywords: Biological invasions, Round goby, Ecosystems, Lake management.*

JETOO, S. and KRANTZBERG, G., McMaster University, 1280 Main St West, Hamilton, ON, L8S 4L8. **The need for governance indicators for the Laurentian Great Lakes.**

The words "if you cannot measure it, you cannot manage it" have famously been attributed to management Guru Peter Drucker and used in numerous situations to justify tangible measurements such as water quality. Is this also applicable to areas that do not seem to lend themselves easily to measurement, such as governance of the Great Lakes? The Great Lakes Water Quality Protocol (The Protocol) was signed on September 7, 2012 and includes key governance elements such as accountability, public engagement, involvement and engagement of indigenous persons, cooperation and collaboration, appropriation of funds, review and reporting. However, there are no indications in the Protocol of how achievement of these objectives will be determined. Further, the most recent IJC's report on assessment of progress, the 16th Biennial report contained 14 indicators of chemical, physical and biological integrity but only two performance measures. This paper argues that governance indicators will be useful in assessing progress of the parties in achieving the purpose of the Agreement and will also aid in showing trends of governance once a baseline is established. This can aid in understanding governance of the Great Lakes and can inform decisions in the implementation of the Protocol. *Keywords: Great Lakes basin, Governance, Indicators, Laurentian Great Lakes, Policy making, Governance Indicators.*

JIAO, Y.[1], REID, K.B.[2], and NUDDS, T.[2], [1]Department of Fish and Wildlife, Virginia Tech, Blacksburg, VA, 24061; [2]Department of Zoology, University of Guelph, Guelph, ON, N1G 2W1. **Alternative Bayesian statistical catch-at-age models for walleye stock assessment in Lake Erie.**

Model construct of stock assessment reflects hypotheses of different key life history and fisheries processes, and have serious implications in fisheries management. In this study, using the Lake Erie walleye (Sander vitreus) fishery as an example, we compared several statistical-catch-at-age models, with different submodels of natural mortality and catchability, to assess the population dynamics. Models that we used included: a state-space statistical catch-at-age model (SCAG) with constant natural mortality, a SCAG with unknown natural mortality but a prior distribution from a tagging study, a SCAG with time-varied natural mortality following a random walk process, a SCAG with a time-varied catchability coefficient following a random walk process, and a SCAG with both natural mortality and catchability following random walk processes. A Bayesian approach was used to estimate parameters, and performance of the models was compared by goodness-of-fit, the retrospective patterns of the models, and the posterior predictive ability. A multi-model inference approach, using a Bayesian model selection algorithm with probability of being selected renewed each year, is discussed when more than one model is plausible for a fishery. *Keywords: Walleye, Bayesian statistical catch-at-age model, Fish populations, Fish management.*

JOHENGEN, T.H.[1], BURTNER, A.[1], PALLADINO, D.[1], RUBERG, S.A.[2], ANDERSON, E.J.[2], SHUCHMAN, R.A.[3], and PURCELL, H.[1], [1]Cooperative Institute for Limnology and Ecosystems Research, 440 Church Street, Ann Arbor, Mi, 48109; [2]National Oceanic and Atmospheric Administration - Great Lakes Environmental Research Laboratory, 4840 S. State Rd., Ann Arbor, Mi, 48108; [3]Michigan Technological Research Institute, Green Road, Ann Arbor, Mi, 48105. **Does it Matter How you Stir the Pot? Examination of Time Series Trends in Water Quality and Harmful Algal Blooms as Related to Wave Events and Hydrodynamics in Western Lake Erie.**

As part of ongoing Harmful Algal Blooms (HABs) research projects through the Center of Excellence for Great Lakes and Human Health, we have operated two continuous monitoring instrumented moorings in western Lake Erie since 2011. Instrumented moorings collected high temporal frequency data for chlorophyll a, phycocyanin, phycoerythrin, CDOM, turbidity, specific conductivity, phosphorus and temperature. Weekly discrete water sample were collected to quantify HABS directly and to validate sensor data. In addition, time series for both waves and currents were generated from the Great Lakes Coastal Forecasting System nowcasts. From the nowcast time series, several significant wave events were analyzed to examine local responses in water quality and HABs and indicate a tight coupling between physical drivers and ecological response. Retrospective analyses are being completed to examine the degree of correlation between the timing and intensity of waves and resulting timing, distribution, or extent of HABS at the lake scale. *Keywords: Harmful algal blooms, Hydrodynamics, Ecosystem health.*

JOHNS, C.M.[1] and FRIEDMAN, K.B.[2], [1]Ryerson University, Jorgenson Hall, Toronto, ON, M5B 2K3; [2]University of Buffalo, Buffalo, NY. **Indicators of Governance Capacity: Great Lakes Governance Networks.**

Moving towards the development of governance indicators requires some analysis of the wide range of actors and organizations involved in Great Lakes governance and their capacity to contribute to policy implementation and outcomes. This paper outlines the value of using network theory from public policy and public administration and social network analysis methods to analyze transboundary and domestic governance networks in the Great Lakes region as governance indicators. It focuses on the value of analyzing networks of public administrators, non-government and private sector actors as contributors to transboundary and binational governance capacity in the region. The paper also outlines the potential of using this approach and social network analysis methods to analyze and compare networks as indicators of governance capacity across scales, jurisdictions and policy domains. *Keywords: Policy making, Environmental policy, Great Lakes basin.*

JOHNSON, J.E.[1], WELLENKAMP, W.[1], and ZELLINGER, J.[2], [1]Michigan Department Natural Resources, Alpena Fisheries Research Station, Alpena, MI; [2]Michigan Department of Natural Resources, Lake St. Clair Fisheries Research Station, Mt. Clemens, MI. **Effects of Changing Food Web and Nutrient Loading on the Nearshore Fish Community of Thunder Bay, Lake Huron.**

In 2012 resource agencies combined to focus on spatial structure and composition of Lake Huron foodwebs. The focus of this presentation is the nearshore fish community in Thunder Bay, Lake Huron. Bottom trawl catches of age-0 whitefish fell to the lowest level in a 27-year time series and total trawl catch fell steadily after 1997. Alewife catches fell to near zero. Walleye catch rates in gillnets were relatively high in June but fell 86% by August. Smallmouth bass catch rates were far below those of other Great Lakes sites at similar latitudes. Age-0 yellow perch and other species apparently avoided daytime bottom trawls but were caught by night trawling and in micromesh gillnets. Few yellow perch older than age 1 were sampled. The Thunder Bay River was a significant source of nutrients to the bay during the 1960s-80s, but nutrient loads have fallen. There was no evidence that Thunder Bay's fish community benefited from nutrients of the River in 2012. Ecosystem re-engineering by dreissenid mussels and proliferations of benthic algae may have negatively affected nearshore fish communities by depriving the water column of nutrients, particularly during spring when many species of larval fish require small zooplankton for first feeding. *Keywords: Fish behavior, Invasive species, Food chains, Nutrients.*

JOHNSON, L.B.[1], BRADY, V.[1], BROWN, T.[1], CIBOROWSKI, J.J.H.[2], DANZ, N.[3], HOWE, R.W.[4], HOST, G.[1], NIEMI, G.J.[1], REAVIE, E.D.[1], WALTON, N.G.[4], GATHMAN, J.[2], and CAI, M.[1], [1]University of Minnesota Duluth, 5013 Miller Trunk Highway, Duluth,, MN, 55811; [2]University of Windsor, Department of Biology, Windsor, ON, N9B 3P4; [3]University of Wisconsin-Superior, Department of Biology, Superior, WI, 54880; [4]University of Wisconsin-Green Bay, Department of Biology, Green Bay, WI, 54311. **Great Lakes Environmental Indicators: Validating Coastal Ecosystem Indicators.**

The Great Lakes Environmental Indicators (GLEI) initiative began in 2001 with an overall goal was to develop indicators that both estimate ecological condition and suggest plausible causes of ecosystem degradation across the NA Great Lakes coastal region based on diatoms, fish, invertebrate, and wetland plant communities. We sampled these biological communities across the U.S. coastal wetlands, uplands, estuaries/bays, and high-energy shorelines. Sample sites were selected as part of a stratified random design for the entire Great Lakes coastal region using gradients of anthropogenic stress that incorporated variables such as agriculture, land cover, human populations, and point source pollution. US sites were sampled from 2001-2004; additional sites were sampled across the CA shoreline from 2011 - 2013. We have identified ecologically relevant indicators that have the greatest possible discriminatory power to distinguish degraded systems from least-impaired systems based on biota from Great Lakes coastal ecosystem relative to the dominant anthropogenic stressors in the watershed. Herein we report on progress in identifying indicators for non-wetland shoreline areas, condition classification accuracy, comparison of indicator development methods and types and present a preliminary map of site conditions across the basin. *Keywords: Indicators, Coastal ecosystems, Bioindicators.*

JOHNSON, L.T., BAKER, D.B., RICHARDS, R.P., ROERDINK, A.R., CONFESOR, R.B., KRAMER, J.W., EWING, D.E., and MERRYFIELD, B.J., National Center for Water Quality Research, Heidelberg University, Tiffin, OH, 44883. **Historical and seasonal trends in nitrogen loading from Lake Erie tributaries.**

Although the form and amount of nitrogen (N) in Lake Erie influences algal bloom dynamics, little is known about long-term trends in tributary N loading to the lake. As a part of the Heidelberg Tributary Loading Program, nitrate-N ($NO_3$-N) and total Kjeldahl N (TKN) have been analyzed daily in five watersheds draining to Lake Erie for up to 38 years. Across all watersheds, $NO_3$-N was the dominate form of N ranging from 59-79% of total N load ($NO_3$-N+TKN). In 2013, $NO_3$-N concentrations were highly variable (below detection - 15.7 mg/L) in the 4 agricultural watersheds (Sandusky, Maumee, Portage, Raisin) and peaked in June even without a major storm event, reflecting application of N fertilizer. $NO_3$-N concentrations were lower (0.03 - 4.7 mg/L) in the urban watershed (Cuyahoga) and also peaked in June, but this was associated with point source inputs during low flow. Over the past 10 years, annual $NO_3$-N flow-weighted mean concentrations have been trending down in all agricultural watersheds, despite increased intensity of tile drainage during this time. Our results indicate strong seasonality in N loading to Lake Erie, which may have implications for the timing and dynamics of algal bloom formation, especially in the agriculturally-dominated Western Basin. *Keywords: Nutrients, Lake Erie, Tributaries.*

JOHNSON, T.A., CRIMMINS, B.S., HOLSEN, T.M., LAING, J.R., and HOPKE, P.K., Clarkson University, 8 Clarkson Avenue, Potsdam, NY, 13699. **Temporal and Spatial Distributions of Mercury and Trace Metals in Great Lakes Trout.**

The Great Lakes Fish Monitoring and Surveillance Program (GLFMSP) is tasked with tracking chemical contamination in the Great Lakes region. Lake Trout (Salvelinus namaycush) are collected from two sites, within each lake, every other year and processed for trace metals and total mercury. Briefly, microwave digestion was followed by ICP-MS analysis using EPA protocol 3052 for trace metals analysis, and mercury concentrations were determined using a Milestone Direct Mercury Analyzer. Spatial and temporal trends were evaluated using SigmaPlot™ and PIA linear regression software. Shallow/nearshore sites in Lake Michigan show increasing mercury concentrations, while deeper/offshore sites have decreasing mercury concentrations. In contrast, Lake Huron deep/offshore and shallow/nearshore mercury concentrations are increasing and decreasing, respectively. The spatial and temporal trends of non-Hg trace metals in the Great Lakes will also be discussed. Overall, the presentation will provide a current picture of trace metals in the Great Lakes Region with an emphasis of potential environmental factors such as food web dynamics and fish age influencing these trends. *Keywords: Mercury, Environmental contaminants, Lake trout.*

JOOSSE, P.J., FEISTHAUER, N.C., SMITH, J.M., and SPERANZINI, D.G., Agriculture and Agri-Food Canada, 174 Stone Road W., Guelph, ON, N1G 4S9. **Using agri-environmental indicators to track changes in the risk of nutrient and sediment losses in the Lake Erie basin: II. Application from watershed scale to the Lake Erie Basin.**

Agriculture and Agri-Food Canada has developed several agri-environmental indicator models for national reporting of trends in environmental risk and conditions in agriculture. Components of these national models can be utilized in a modular fashion to inform regional scale issues such as water quality in Lake Erie. The concept of using the source and transport components from the indicators for loss of phosphorus, nitrogen and soil from agricultural landscapes that was piloted in a study of the Grand River watershed (presented in "Using agri-environmental indicators to track changes in the risk of nutrient and sediment losses in the Lake Erie basin: I. Grand River Case Study") is being extended to the Lake Erie basin. The models utilize Census of Agriculture information since 1981, allowing a 30 year time series analysis of changes of risk on the landscape and whether or not improvements are being maintained. A farming systems typology has also been developed to better understand the characteristics and distribution of agricultural production systems in the Canadian Lake Erie basin and to facilitate "customization" of recommendations and research by production system. This presentation will present the concepts developed and results for the Lake Erie basin. *Keywords: Management, Agriculture, Nutrients, Phosphorus.*

# K

KALCIC, M.M.[1], BOSCH, N.B.[2], and SCAVIA, D.[1], [1]Graham Sustainability Institute, 625 E. Liberty, Suite 300, Ann Arbor, MI; [2]Center for Lakes & Streams, Grace College, 200 Seminary Drive, Winona Lake, IN, 46590. **Using SWAT to Estimate Watershed-scale BMP Performance in the Western Lake Erie Basin.**

Agricultural runoff to tributaries draining into the Western Lake Erie Basin is a primary source of excess phosphorus that drives hypoxia and harmful algal blooms in Lake Erie. While best management practices (BMPs) are capable of reducing phosphorus loading from agricultural activities, they are generally applied at the field scale, and yet the pollution concern in Lake Erie requires watershed-scale management. We used the Soil and Water Assessment Tool (SWAT) to model agricultural practices and estimate nutrient loading from several Western Lake Erie tributaries. Multiple "what if" scenarios for BMP selection and placement within the watersheds were then tested to determine the relative performance of several BMPs in reducing pollution loading to Lake Erie. *Keywords: Watershed modeling, Water quality, Lake Erie.*

KAMMIN, L.K., Illinois-Indiana Sea Grant, University of Illinois, 1101 W. Peabody Dr., Urbana, IL, 61856. **Emerging Contaminants: Pharmaceuticals and Personal Care Products in the Great Lakes.**

Illinois-Indiana Sea Grant (IISG) has been working to increase knowledge about pharmaceutical and personal care products (PPCPs) in the environment, specifically their sources, fate, and potential impacts on human, animal, and environmental health. We seek practical solutions for the design, use, and management of PPCPs. IISG takes a multi-pronged approach to reducing the load of PPCPs reaching Lake Michigan and other waterways within the Great Lakes Basin: 1) funded research, 2) education and outreach programs, 3) social media, 4) partnerships, and 5) collaboration on a multi-state Great Lakes Restoration Initiative (GLRI) funded project, *Undo the Great Lakes Chemical Brew*. Working with other organizations, we strive to use the latest science on emerging contaminants to empower people to solve problems in sustainable ways. *Keywords: Great Lakes Restoration Initiative (GLRI), Microplastics, PPCP, Environmental education, Environmental contaminants, Lake Michigan.*

KAO, Y.C. and ADLERSTEIN, S.A., Univ. of Michigan, School of Natural Resources and Environment, 440 Church Street, Ann Arbor, MI, 48109. **Relative Importance of Top-down and Bottom-up Effects on the Collapse of Alewife Population in Lake Huron.**

We used an Ecopath with Ecosim modeling approach to analyze relative importance of top-down and bottom-up effects on the collapse of alewife population in Lake Huron. We configured two food web models in Ecopath: one for 1984 before the invasions of dreissenid mussels and round goby and one for 2002, the year before alewife population collapse. We implemented the models with data on organism biomass, production, consumption, and diet from government surveys and other sources. We conducted a mixed trophic impact analysis to access the net (direct and indirect) effects from food web groups on alewives. Results showed that top-down effects from Chinook salmon and lake trout predation had stronger control on alewife biomass than bottom-up effects from primary productivity and biomass of cladocerans and *Diporeia*; and effects of dreissenid mussels were stronger on the biomass of young-of-the-year alewives but are less important to the biomass of age-1 and older alewives. Results also showed that rainbow smelts had negative effects on alewives in 1984 when their biomass was large but positive effects in 2002 when their biomass was

small, suggesting that low biomass of rainbow smelts did strengthen the predation pressure on alewives. *Keywords: Food chains, Lake Huron, Ecosystem modeling.*

KAO, Y.C.[1], MADENJIAN, C.P.[2], BUNNELL, D.B.[2], and LOFGREN, B.M.[3], [1]Univ. of Michigan, School of Natural Resources and Environment, 440 Church Street, Ann Arbor, MI, 48109; [2]USGS, Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105; [3]NOAA Great Lakes Environmental Research Laboratory, 4840 South State Road, Ann Arbor, MI, 48108. **Potential Effects of Climate Change on the Growth of Five Economically Important Fishes in Lake Huron.**

We used a bioenergetics modeling approach to investigate potential effects of climate change on the growth of Chinook salmon, lake trout, steelhead, lake whitefish, and yellow perch in Lake Huron. Potential changes in fish growth were assessed by contrasting the modeled growth in the projected climate regime of the future period (2043-2070) under different prey availability scenarios to the modeled growth in the observed climate regime of the baseline period (1964-1993). Our results showed that the growth of these fishes will decrease in the warming climate if prey availability remains constant. Estimated prey consumption required to maintain current growth in the future period were by 13%, 10%, 6%, 2%, and 2% higher than baseline levels for yellow perch, Chinook salmon, steelhead, lake trout, and lake whitefish, respectively. Under the high prey availability scenario, modeled future growth of these fishes all increased but the growth of yellow perch increased least while that of the other four fishes increased at similar levels. Our results suggested that changes in fish growth in response to the warming climate in Lake Huron will depend on prey availability, physiological thermal optimum, and diet composition. *Keywords: Fish management, Bioenergetics, Lake Huron.*

KARATAYEV, A.Y.[1], BURLAKOVA, L.E.[1], and PADILLA, D.K.[2], [1]Great Lakes Center, SUNY Buffalo State, 1300 Elmwood Avenue, Buffalo, NY, 14222; [2]Department of Ecology and Evolution, Stony Brook University, 650 Life Sciences Building, Stony Brook, NY, 11794-5245. **Spread, population dynamics and ecosystem impacts of zebra versus quagga mussels.**

Zebra (*Dreissena polymorpha*) and quagga (*D. rostriformis bugensis*) mussels have similar life history characteristics, but differ in their rates of spread, habitat requirements, and population dynamics. Their overall ecological impacts depend on the number of waterbodies colonized, total population density and spatial distribution in a given waterbody. Both species provide additional space and food for invertebrates in the littoral zone, increasing their diversity and density. In contrast, in the profundal zone quagga mussels compete for space and food with benthic invertebrates, decreasing their diversity and density. The system-wide effect of dreissenids depends on water mixing rates and lake morphology. Because quagga mussels are found in all regions of a lake, and form higher population sizes, they may filter larger volumes of water and may have greater system-wide effects than zebra mussels, especially in deep lakes. While the zebra mussel is among the best studied freshwater invertebrates, we do not always have comparable information for quagga mussels, which limits our ability to predict the spread and ecological impacts of this important freshwater invader. *Keywords: Dreissena, Ecosystems, Invasive species.*

KARATAYEV, V.A.[1], RUDSTAM, L.G.[2], WEIDEL, B.C.[3], WATKINS, J.M.[2], and WALSH, M.G.[3], [1]Office of Undergraduate Biology, 216 Stimson Hall, Cornell University, Ithaca, NY, 14853; [2]Cornell Biological Field Station, 900 Shackelton Point Road, Bridgeport, NY, 13030; [3]USGS Lake Ontario Biological Station, Oswego, NY, 13126. **Monitoring the ecological impacts of Dreissena: characterizing drivers and gradients of density, biomass, and population structure in Lake Ontario.**

Dreissenids have strongly reduced basal pelagic energy sources, shifted nutrient flow to the bottom sediments, and have come to dominate (>95%) benthic invertebrate biomass during the ~25 years since they invaded the Great Lakes. Determining the extent to which dreissenids affect the spatial variability (e.g. areas where nutrient shunt by mussels is strongest) and long-term dynamics of these ecosystems requires knowledge of *Dreissena* population dynamics. However, dreissenid abundance and biomass may be decoupled and certainly have a high spatiotemporal variability, impeding an assessment of dreissenid ecological impacts. During intensive monthly April-November sampling along a nearshore-offshore (5-200m depth) gradient in Lake Ontario, we found a peak in dreissenid biomass at 50m, a peak in abundance at 100m, and strong differences in population structure and recruitment between < 50m and > 100m depths. Data from other locations in Lake Ontario, however, indicate that these shifts occur at different depths, confounding our predictions of the areas where the ecological impacts of dreissenids are highest - as well as lakewide (depth-weighted) population estimates. We also explore the concomitance of *Dreissena* abundance, biomass, and population dynamics with phytoplankton availability throughout the growing season. *Keywords: Dreissena, Environmental effects, Spatial distribution.*

KEELER, K.M., DEBRUYNE, R.L., HUNTER, R.D., PROVO, S.A., ROSEMAN, E.F., and SUTHERLAND, J.L., USGS-Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105. **Connecting the Lower Food Web between Lakes: Zooplankton of the St. Clair-Detroit River System 2012-2013.**

The St. Clair-Detroit River System (SCDRS) comprises portions of three lakes (Huron, St. Clair, and Erie) connected by the St. Clair and Detroit rivers. It is an important spawning and nursery location for numerous native fishes that support vibrant sport and commercial fisheries. But characterization of potential prey from the lower food web, such as crustacean zooplankton, has been either limited or non-existent. From March-August 2012 and March-December 2013, zooplankton were sampled throughout 13 sites in the SCDRS to measure community density and biomass changes. Spring samples were dominated by *Leptodiaptomus* spp., with few non-native species. Mean biomass was significantly higher in the St. Clair River than the Detroit River in both years (1,371 and 4,710 μg/m$^3$ vs. 747 and 1,663 μg/m$^3$ respectively) while densities were similar in both rivers within years (320/m$^3$ and 363/m<sup3 in 2012 and 1,385 and 1,265/m$^3$ in 2013). Summer and fall samples will also be compared to provide a valuable baseline for future comparisons as habitat and population restoration efforts continue to be assessed. These analyses will help elucidate linkages between not only trophic levels, but the potential impact Lake Huron's altered foodweb has had on lower Great Lakes. *Keywords: Lake Huron, Lake St. Clair, Species composition, St. Clair River, Zooplankton, Detroit River.*

KELLY, N.E.[1], MOLOT, L.A.[1], YOUNG, J.D.[2], and STAINSBY, E.[2], [1]Faculty of Environmental Studies, York University, Toronto, ON, M3J 1P3; [2]Ontario Ministry of the Environment, 125 Resources Road, Toronto, ON, M9P 3V6. **Cold-water fish optimal habitat in Lake Simcoe: long-term trends and relationships to climate change and total phosphorus.**

By the 1970s, high total phosphorus inputs to Lake Simcoe had contributed to the deterioration of hypolimnetic water quality, and subsequently the decline of cold-water fish populations. Since the 1980s, ongoing management efforts have led to recent improvements in these metrics; however, the impact of climate warming on optimal cold-water fish habitat is currently unknown, and in future may counter-act the improvements resulting from nutrient reduction efforts. We used long-term temperature and dissolved oxygen profile data from 1980-2012 to quantify trends in the optimal available habitat volumes (OAHV) for lake trout and whitefish. The late summer OAHV, and the day of the year when the minimum OAHV first occurred, significantly increased since the 1980s for adult lake trout and whitefish. This is possible as the amount of OAHV lost due to reduced oxygen availability has significantly decreased over this period. One additional concern, however, is that the 4-8 °C thermal refuge for juvenile lake trout was non-existent in late summer in 10 of the 17 years between 1996 and 2012. Ongoing efforts to develop an empirical model to examine changes to the cold-water fish habitat under various climate warming and nutrient loading scenarios will also be discussed. *Keywords: Fish populations, Optimal habitat, Oxygen, Climate change.*

KENOW, K.P.[1], FOX, T.J.[1], KRATT, R.[1], HOUDEK, S.C.[1], FARA, L.J.[1], CRIMMINS, S.[1], ROBINSON, L.R.[1], BOMA, P.J.[1], LUBINSKI, B.R.[2], HEARD, D.J.[3], and MEYER, M.W.[4], [1]U.S. Geological Survey, 2630 Fanta Reed Road, La Crosse, WI, 54603; [2]U.S. Fish and Wildlife Service, 5600 Amercian Blvd. W. Suite 990, Bloomington, MN, 55437; [3]University of Florida, Box 100126, Gainesville, FL, 32610; [4]Wisconsin Department of Natural Resources, 107 Sutliff Avenue, Rhinelander, WI, 54501. **Distribution and Foraging Patterns of Waterbirds on Lake Michigan with Implications for Exposure to Botulinum Toxin.**

Waterbird die-offs resulting from type E botulism were first documented in Lake Michigan during the early 1960s. In recent years, occurrences of botulism-related mortality have been reported throughout several of the Great Lakes and outbreaks have increased in frequency. The actual sites of toxin exposure among birds remain unclear and the physical and ecological factors that lead to botulism outbreaks are poorly understood. Central to this question are feeding patterns and exposure routes of sentinel waterbird species, such as common loons (Gavia immer), historically at risk to botulism die-offs. During the autumns of 2010-2013, we examined the distribution of waterbirds using Lake Michigan through aerial surveys and documented the migration movements and foraging patterns of common loons equipped with archival geo-locator tags and satellite transmitters. Radiomarked loons frequented areas up to 35 km offshore in up to 60 m water depth. Evidence suggests common loons forage on bottom-dwelling fish in Lake Michigan at depths up to 45 m. Waterbird distribution data are being used to derive species-specific habitat associations and to inform a hydrodynamic carcass source tracking model. The results of this work are expected to elucidate where waterbirds are likely to be exposed to forage harboring type E botulinum toxin. *Keywords: Lake Michigan, Avian ecology, Distribution patterns.*

KIM, D.K.[1], ZHANG, W.[1], MUGALINGAM, S.[2], GEATER, K.[3], MORLEY, A.[4], MCCLURE, C.[5], KEENE, B.[5], WATSON, S.B.[3], DITTRICH, M.[1], and ARHONDITSIS, G.B.[1], [1]University of Toronto, Ecological Modelling Laboratory, Toronto, ON, M1C 1A4;

[2]Lower Trent Conservation, Trenton, ON; [3]Environment Canada, Toronto, ON; [4]Ontario Ministry of the Environment, Toronto, ON; [5]Quinte Conservation, Bellevile, ON. **Phosphorus dynamics in the Bay of Quinte: What do the models predict?**

We evaluate the relative importance of the causal connections among the exogenous total phosphorus loading, internal nutrient recycling, and the water quality conditions in the Bay of Quinte, Ontario, Canada. First, we examine the temporal trends of all the major point and non-point loading sources over the last four decades. We then use an integrated watershed (SPARROW)-receiving waterbody model to examine the effects of a number of land-use management scenarios on the phosphorus dynamics in the Bay of Quinte as well as their broader implications for the ecosystem functioning. With the exception of Napanee River, the temporal variability of the total phosphorus levels in the major tributaries of the Bay of Quinte watershed is indicative of a distinctly declining trend. The same decreasing trend characterizes the dissolved phase (and readily bioavailable) fraction which typically accounts for less than 20% of the amount of phosphorus that enters the Bay. Our analysis also provides evidence that phosphorus dynamics in the upper Bay are predominantly driven by the inflows from Trent River, while the middle and lower segments receive substantial internal subsidies from the sediment diagenesis mechanisms and/or the activity of macrophytes and dreissenids (e.g., pseudofeces production, nutrient pump effect). *Keywords: Environmental modeling, Watersheds, Eutrophication, Bay of Quinte, Nutrients, Non-point pollution.*

KIRKPATRICK, A.[1], LOGAN, T.[2], and COPPLESTONE, D.[3], [1]Ontario Federation of Anglers and Hunters, 4601 Guthire DR, PO Box 2800, Peterborough, ON, K9J 8L5; [2]Federation of Ontario Cottagers' Association, #201 - 159 King St, Peterborough, ON, K9J 2R8; [3]Ontario Ministry of Natural Resources, 300 Water Street, Peterborough, ON, K9J 8M5. **Engaging Lake Associations in Aquatic Invasive Species Monitoring: A Citizen Science Approach.**

Citizen science based monitoring is becoming increasingly utilized by management agencies to leverage limited funding. The early detection and rapid response of aquatic invasive species (AIS) is essential in preventing their introduction, establishment, or spread. In partnership with the Ontario Ministry of Natural Resources (OMNR) and the Ontario Federation of Anglers and Hunters (OFAH), the Federation of Ontario Cottagers' Associations (FOCA) has launched the Lake Associations Aquatic Invasive Species Citizen Science Monitoring Program. The volunteer citizen science monitoring program will engage lake association members in monitoring for aquatic invasive plants. New and existing educational resources will be used to educate volunteers on AIS identification, and how to conduct moni-

toring using a citizen science based aquatic plant monitoring protocol, which utilizes the Early Detection and Distribution Mapping System (EDDMapS). EDDMapS Ontario is a web based invasive species mapping and reporting tool developed by the OFAH, OMNR, and the Invasive Species Centre. The delivery of the Lake Associations Aquatic Invasive Species Citizen Science Monitoring Program will promote education and awareness of AIS, facilitate early detection and rapid response of AIS, and facilitate monitoring and data collection for EDDMapS Ontario. *Keywords: Invasive species, Citizen science, Monitoring.*

KIRKWOOD, A.E., BEDJERA, S., COMEAU, G., STRANGWAY, C., and VINCENT, J., Faculty of Science, University of Ontario Institute of Technology, 2000 Simcoe St. N., Oshawa, ON, L1H 7K4. **Linking water quality and contaminant fate to biological diversity and function in urban surface waters.**

With increasing urbanization of watersheds in the lower Great Lakes basin, there is an increased need to improve our understanding of urban impacts to aquatic ecosystem function. In Durham Region, ON, tributaries drain from headwaters in the Oak Ridges Moraine to the north-central shores of Lake Ontario. Watersheds in the region typically experience an agriculture-urbanization gradient from north-south. Stormwater is primarily managed by stormwater management ponds or direct sewer drainage in older areas. We conducted studies on urban wetlands, stormwater management ponds and a tributary to assess the impacts of urbanization on ecosystem diversity (bacteria, algae and zooplankton) and function, including the capacity for in situ biodegradation of organic contaminants. Our results indicate that increased urbanization, as inferred by water conductivity, total suspended solids and % impervious surface in the watershed, fundamentally changed community composition and to a lesser extent, production. In situ biodegradation of organic contaminants (2, 4-D and 3-CBA) was relatively slow, suggesting a diminished role for microbial contaminant removal in stormwater management ponds and wetlands. *Keywords: Lake Ontario, Wetlands, Biotransformation, Phytoplankton, Environmental contaminants, Microbial.*

KLEIST, C.S., City of Duluth Minnesota, Engineering Department, 411 West First Street Room 211, Duluth, MN, 55802. **City of Duluth Stream Restoration and Recovery after the 500 Year Flood.**

On June 19-20th, 2012 the City of Duluth, Minnesota and surrounding area received 5 to 10 inches of rain over a 36 hour period. The official Duluth 24 hour rainfall was 6.90 inches; which set a new 24 hour rainfall record and placed this event in the probability of

occurrence of 500 years. The widespread damage to roads, bridges, culverts, railroads, and storm sewers has been estimated at over $100 million. This presentation begins with a background of Duluth's unique steep and rocky topography that contributed to the extensive flooding damage. Mr. Kleist will cover the Duluth's aging storm sewer system and the importance of protecting Duluth's sixteen DNR designated cold water trout streams through a variety of specialized Best Management Practices (BMPs) and innovative stormwater management techniques. The presentation will focus on the ongoing recovery efforts related to stream restoration that Mr. Kleist is coordinating. Repairing damage to trout streams offers many complex challenges as the City works across several jurisdictions balancing many different funding sources and timelines. *Keywords: Water quality, Flood recovery, Trout, Streambank stabilization, Urban watersheds, Stream restoration.*

KLUMP, J.V.[1], FERMANICH, K.J.[2], KENNEDY, J.[3], LABUHN, S.[1], VALENTA, T.[3], WAPLES, J.T.[1], and ZORN, M.[2], [1]University of Wisconsin-Milwaukee, School of Freshwater Sciences, Great Lakes WATER Institute, Milwaukee, WI, 53204; [2]University of Wisconsin-Green Bay, Green Bay, WI, 54311; [3]Green Bay Metropolitan Sewerage District, NEW-Water, Green Bay, WI, 54302. **Dolan, Data and Green Bay.**

Dave Dolan was a maestro of data. Green Bay was one of his loves. The links between phosphorus loading, eutrophication and hypoxia were some of his driving concerns. The historical trends in Green Bay are something of a puzzle, one that Dolan would have loved to decipher. Despite the largest PCB cleanup effort in the country in the lower Fox River, Green Bay augurs to remain a system with significant water quality problems as a result of decades of excessive nutrient loading and hypereutrophic conditions. We will examine at some of the unique long term records in the bay for phosphorus concentrations, oxygen conditions, and sedimentation, and examine their possible linkages to both internal and external processes. *Keywords: David Dolan, Green Bay, Eutrophication.*

KOCH, K.[1], FAVERI, G.R.[2], GRANNEMAN, N.G.[3], PAIGE, K.[4], and SLAWECKI, T.A.D.[1], [1]LimnoTech, 501 Avis Dr Ste 1, Ann Arbor, Mi, 48108; [2]Environment Canada, 857 Lakeshore Road, Burlington, ON, L7R 4A6; [3]U.S. Geological Survey, 6520 Mercantile Way, Suite 5, Lansing, MI, 48911; [4]Great Lakes Observing System, 229 Nickels Arcade, Ann Arbor, MI, 48104. **GEO Great Lakes: A Framework For Bi-national Data Sharing.**

The Group on Earth Observations (GEO) is building a Global Earth Observation System of Systems (GEOSS) that links together existing and planned observing systems around the world and provides decision-support tools. In the Great Lakes, GEO Great Lakes (GEO-GL) is part of GEOSS and supports data collaboration efforts between the United States and Canada in the Great Lakes Region. These efforts contribute to the efficacy of adaptive management.Members of Environment Canada, the National Oceanographic and Atmospheric Administration, US Environmental Protection Agency, US Geological Survey, and others work to make bi-national datasets *discoverable* (easy to find), *transparent* (easy to understand ) and *interoperable* (easy to use). These needs are met through application of internationally accepted standards that ensure that the data are accurate, consistent and verified.GEO-GL is actively working to link datasets and data owners with resource managers and other data users by helping the data owners publicize (through metadata) and publish their holdings.The poster will introduce GEO, GEOSS, and GEO-GL, provide an overview of GEO-GL protocols, and present illustrative examples of standards-compliant data publicity and publication that address bi-national resource management goals for the Great Lakes. *Keywords: Data storage and retrieval, Decision making, Management.*

KOSMENKO, N.J.[1], SEMENIUK, C.[1], DROUILLARD, K.G.[1], and JOHNSON, T.B.[2], [1]Great Lakes Institute for Environmental Research, University of Windsor, 401 Sunset Avenue, Windsor, ON, N9B 3P4; [2]Glenora Fisheries Station, Ontario Ministry of Natural Resources, 41 Hatchery Lane, Picton, ON, K0K 2T0. **Bioenergetics Modeling to Assess Aquatic Invasive Species Impact.**

The effects aquatic invasive species (AIS) have on biodiversity, productivity, and ecosystem services cost North Americans billions of dollars annually and significantly alter the quality and opportunities associated with previously derived benefits. As it is difficult to predict impacts AIS will have, much of current AIS management occurs after the fact, which is expensive and time-consuming. Since rates of food consumption and metabolism of fish may provide insight into the magnitude of potential trophic impacts of AIS, correlations between these rates and fish life history traits may help identify general patterns reflective of the relative impact of introduced species. In this analysis, a database was developed using published literature to track information on fish life history traits. The database was then examined for relationships between morphometric, physiological, and ecological traits against maximal consumption and basal metabolic rates. Next, the above relationships were contrasted between native and invasive fish over similar ranges of biological attributes to determine if metabolic features differ between the two categories. The ability to predict trophic impacts from examination of easily attainable traits will provide managers with a cost-effective tool to support risk assessment and decision-making. *Keywords: Invasive species, Fish, Bioenergetics.*

KÖSTER, D., KARST-RIDDOCH, T.L., and HUTCHINSON, N.J., Hutchinson Environmental Sciences Ltd., 501 Krug Street, Suite 202, Kitchener, ON, N2G 1L3. **Differing Susceptibility to Eutrophication in two Georgian Bay Embayments due to Hydrology: Evidence from the Paleolimnological Record in Support of a Citizen-Based Monitoring Program.**

Nutrient enrichment from shoreline development in Georgian Bay embayments is a concern of local residents. Monitoring by Georgian Bay Forever (GBF), a citizens group, has provided valuable information on water quality, but changes due to human impacts are unknown as no data pre-date settlement and shoreline development. GBF therefore funded a paleolimnology study to describe natural conditions and human impacts on water quality in two Georgian Bay embayments. Sediment cores from North and South Bay were analyzed for a suite of biological indicators to reconstruct past trends in nutrients, algae, oxygen levels and macrophyte abundance. Minor changes occurred after early settlement in the 1800s, but later changes in the 1900s suggest moderate increases in nutrients and anoxia. North Bay changed much less than South Bay, likely due to hydrological differences. North Bay has greater exchange of water with Georgian Bay and hence a larger nutrient dilution potential. Moreover, North Bay receives water from local runoff likely resulting in a much lower nutrient load than for South Bay which receives inputs from a river draining a large upstream watershed. Paleolimnology provided a cost-effective means to fill gaps in conventional monitoring data and to place future monitoring observations in the context of baseline conditions. *Keywords: Nutrients, Water quality, Georgian Bay.*

KOVAC, V., Comenius University, Faculty of Natural Sciences, Department of Ecology, Mlynska dolina B2, Bratislava, 84215, Slovakia. **Ten Years Of Successful Invasion Of Round Goby *Neogobius Melanostomus* In The River Danube (Central Europe) - A Review.**

As the second longest river in Europe, the Danube serves as an important waterway across the continent. Such a geographical predisposition, together with intensive shipping, makes the Danube an ideal route for biological invasions. Indeed, over the last two decades, four Ponto-Caspian species of the genus *Neogobius* have invaded the middle and upper stretches of the river. The most successful appears to be the round goby *Neogobius melanosto-*

*mus* that still continues on spreading and establishing new populations, and has penetrated through the Rivers Danube and Rhine (across the continent) up to the North Sea. The initial introduction of round goby upstream the Danube was promoted by international shipping. Results of our own research since the start of the invasion (10 years ago), together with other published data on the species' invasion biology in the Danube are reviewed and analysed. The analysis includes variability in morphology, life-history traits, feeding ecology, phenotypic plasticity, the possible impact of round goby on the native ecosystem, as well as theoretical concepts developed to better understand why the invasion of this species is so successful. *Keywords: Life history studies, Theory of alternative ontogenies, Invasive species, Phenotypic plasticity, Round goby, Long-term study.*

KOVALENKO, K.E.[1], CIBOROWSKI, J.J.H.[2], JOHNSON, L.B.[1], BHAGAT, Y.[2], BRADY, V.[1], BROWN, T.[1], DANZ, N.[3], GATHMAN, J.[4], HOST, G.[1], HOWE, R.W.[5], NIEMI, G.J.[1], and REAVIE, E.D.[1], [1]University of Minnesota Duluth, Natural Resources Research Institute, Duluth, MN, 55811; [2]University of Windsor, Department of Biology, windsor, ON, N9B3P4; [3]University of Wisconsin Green Bay, Department of Biology, Green Bay, WI; [4]University of Wisconsin Superior, Department of Biology, Superior, WI; [5]University of Wisconsin River Falls, Department of Biology, River Falls, WI. **Biological Indicators of the Condition of Great Lakes Exposed Coastal Margins.**

Increasing interest in the biological condition of lentic systems has fostered development of a wide variety of approaches and indices to assess ecological condition of sheltered habitats, which are typically recognized for their biodiversity and ecological services. Few guidelines exist for assessing habitats bordering exposed shorelines, despite their representing over 90% of the Great Lakes coastline. As part of the Great Lakes Environmental Indicators Initiative (GLEI) we present a number of indices derived to assess condition of coastlines using assemblages including birds, invertebrates, fishes and diatoms. These are calibrated against land-based stresses contributed by amount of agricultural land and human development in watersheds draining into the Great Lakes. Watersheds that had >10% of the watershed devoted to agriculture or > the 8th percentile of a composite index representing population supported taxonomic assemblages considered to be nonreference. Fish assemblages characteristic of exposed margins were not substantially different from those of coastal wetlands and embayments. *Keywords: Coastal ecosystems, Stressor gradient, Bioindicators, Indicators.*

KOWALSKI, K.P. and BICKFORD, W.A., USGS, 1451 Green Road, Ann Arbor, MI, 48105. **Developing Microbe-based Management Strategies to Control Invasive *Phragmites australis*.**

Current methods to control invasive *Phragmites australis* (e.g., repeated herbicide, burning) on the North American landscape are resource-intensive and often ineffective. Though management efforts often can produce short-term successes, continued rigorous follow-up is required to prevent recolonization. Innovative control methods are needed to develop more sustainable, long-term, landscape-level strategies. To address this need, the USGS - Great Lakes Science Center has been exploring new management tools to reduce the competitive abilities of *Phragmites*. One line of research explores its relationship with systemic microbes. It is well documented that microbial associations (e.g., mutualisms) greatly influence the colonizing success and production of many plants. Thus, if the associations between invasive *Phragmites* and its microbes can be disrupted, the competitive advantage of *Phragmites* may be reduced and native plant assemblages can be maintained. Our work investigates the role of symbiosis between *Phragmites* and its endophytic fungi and explores opportunities to disrupt or enhance those symbiotic relationships. This research seeks to augment current control efforts to allow managers to fight the spread on multiple fronts, thereby improving overall management effectiveness. *Keywords: Invasive species, Phragmites australis, Management.*

KRONLEIN, M.R.[1], STEDTFELD, R.D.[1], DREELIN, E.A.[2], LATIMORE, J.A.[3], STEVENSON, R.J.[4], and HASHSHAM, S.A.[1], [1]Department of Civil and Environmental Engineering, Michigan State University, East Lansing, MI, 48824; [2]Center for Water Sciences, Michigan State University, East Lansing, MI, 48824; [3]Department of Fisheries and Wildlife, Michigan State University, East Lansing, MI, 48824; [4]Department of Zoology, Michigan State University, East Lansing, MI, 48824. **Environmental DNA (e-DNA) Monitoring of High-risk Invasive Species in the Great Lakes Area Using Gene-Z.**

Detection of aquatic invasive species at very low levels is critical for their eradication. Traditional techniques are time consuming and expensive and may often be less sensitive. An alternative is an environmental DNA (e-DNA) based approach which is more rapid but is not as well developed or field validated. We developed an e-DNA based approach combined with a sample concentration strategy for detection of high risk invasive species at low abundances. A real time isothermal DNA amplification microfluidic chip was designed to simultaneously detect six high risk invasive species using a portable device (Gene-Z). Primers were designed for golden mussel, hydrilla, fishhook waterflea, northern snakehead, killer shrimp, and Daphnia. To allow field validation of the developed method, a number of surrogates were also measured. The method was rapid (< 30 minutes) and low cost ($3 per chip), and did not required DNA extraction. Sensitivity was enhanced by concentrating veligers, juveniles, and eggs using a 35µm filter. Currently samples have been analyzed from more than 50 lakes in Michigan. Golden mussel was absent in all samples, quagga mussel was detected in some samples and zebra mussel was detected in the majority of the samples. These results illustrate the potential of e-DNA based approaches for invasive species monitoring. *Keywords: Invasive species, Environmental DNA, Great Lakes Restoration Initiative (GLRI), Great Lakes basin.*

KRUMWIEDE, B.S.[1], HEROLD, N.D.[2], and MARCY, D.C.[2], [1]The Baldwin Group at NOAA Coastal Services Center, 2234 South Hobson Avenue, Charleston, SC, 29405; [2]NOAA Coastal Services Center, 2234 South Hobson Avenue, Charleston, SC, 29405. **Analyzing and Visualizing Change in the Great Lakes: Past, Present, and Future.**

Through its Coastal Change Analysis Program (C-CAP), the National Oceanic and Atmospheric Administration's Office of Ocean and Coastal Resource Management/Coastal Service Center produces nationally standardized land cover and change information for the coastal regions of the United States. Recent data collection and processing efforts have expanded C-CAP's temporal coverage to 25 years for the Great Lakes and provide inventories of coastal intertidal areas, wetlands, and adjacent uplands using documented, repeatable procedures, with the goal of monitoring these habitats every five years. Work has also begun on the development of the Lake Level Viewer (LLV), a new tool and dataset, based on topobathy LiDAR data and focused on visualizing changes in Great Lakes water levels and the resulting impact on coastal regions. This tool will help to visualize historical and potential future changes in long term average water levels and serve as a useful decision support tool for coastal management efforts. This presentation will summarize some of the major data developments in the C-CAP and LLV programs covering the Great Lakes and will discuss the various ways that users can access existing data. In addition, we will highlight C-CAP data for potential wetland modeling efforts and LLV visualization examples and potential use cases. *Keywords: Water level fluctuations, Land cover change, Remote sensing, Land use, Great Lakes Restoration Initiative (GLRI), Inundation.*

KUCZYNSKI, A.[1] and AUER, M.T.[2], [1]Department of Civil and Environmental Engineering, 1400 Townsend Drive, Houghton, MI, 49931; [2]Great Lakes Research Center, 1400

Townsend Drive, Houghton, MI, 49931. **Management implications of *Cladophora* resurgence in the Great Lakes.**

*Cladophora* growth is limited by phosphorus (P). P limits in WWTP effluents in the 1970s apparently helped curb previously excessive algal growth, but nuisance conditions have returned since the invasion of dreissenids in the 1990s. The literature speaks of the 'resurgence' of *Cladophora*, but there is no widely accepted definition of this phenomenon. Nuisance growth, defined here as the amount of biomass available for deposition on beaches, depends on both the growth rate and the colonizable area. Both are ecosystem engineering outcomes of dreissenids, but only P is manageable. Management depends on the dominating factor. Here, we look at biomass densities, tissue P (directly related to the growth rate by Droop), and areal extent as shown by satellite imagery over three time periods: 1) pre-treatment, pre-dreissenids (early 1970s); 2) post-treatment, pre-dreissenids (1980s); and 3) post-treatment, post-dreissenids (2000s). Lake Ontario shows no change in biomass density, decreasing tissue P, and increasing colonizable area since the dreissenid invasion. Resurgence is more a function of colonization than nutrient enrichment in this lake, but it is urban influences that allow increases in colonizable substrate to cause the resurgence; the alga does not benefit from increasing available area in P poor regions. *Keywords: Cladophora, Dreissena, Phosphorus.*

KULASA, M.R.[1], MAY, C.J.[1], MARSCHALL, L.A.[1], ROSEMAN, E.F.[2], and LUDSIN, S.A.[1], [1]Aquatic Ecology Lab, The Ohio State University, 1315 Kinnear Road, Area 200, Columbus, OH, 43212; [2]USGS - GLSC, 1451 Green Rd, Ann Arbor, MI, 48105. **Impact of Zooplankton Availability on Larval Walleye Diet Selectivity and Growth Rate in Western Lake Erie.**

Prey availability during the larval production period can be a strong regulator of year-class strength as reduced availability of preferred prey may limit survival to older life stages. In Lake Erie, Walleye (*Sander vitreus*) have not had a strong year-class since 2003, with the mechanisms underlying this string of weak year-classes being largely unknown. Towards helping understand variation in year-class strength, we explored relationships among zooplankton (prey) availability and larval walleye diet biomass, prey electivity (Manly-Chesson index), and growth rates during 1994-1995 and 2011-2013. We found that zooplankton availability and size was often low during weak year-classes (2011-2013), which also was reflected in the diets and growth rates of larvae. Overall, our findings help to explain why only weak year-classes have been observed during recent years. *Keywords: Fish diets, Lake Erie, Walleye.*

# L

LAM, V.[1], MACRAE, M.L.[1], ENGLISH, M.C.[2], O'HALLORAN, I.[3], and WANG, Y.[3], [1]Department of Geography and Environmental Management, University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L 3G1; [2]Department of Geography and Environmental Studies, Wilfrid Laurier University, 75 University Avenue West, Waterloo, Ontario, Waterloo, ON, N2L 3C5; [3]Ridgetown Campus, University of Guelph, 120 Main Street East, Ridgetown, ON, N0P 2C0. **The role of seasonality on phosphorus export in agricultural soils from tile drainage under different tillage practices.**

Agricultural watersheds have been identified as a source of nutrients to surface water bodies, contributing to water quality degradation. No-till (or reduced till) management practices have been employed to reduce the potential for particulate P loss. However no-till (NT) may increase soluble-P transport into tile drains. The objectives of this project are to quantify year round losses of runoff, soluble P (SRP) and total P (TP) from drainage tiles beneath conventional till (CT), rotational till (RT) and NT plots, and to investigate the role of seasonality on runoff and P losses. Results indicate that both runoff and P-export are episodic across all tillage plots, and most losses occurred during a few key events under heavy precipitation or snowmelt events. Runoff and P losses through drainage tiles are primarily observed between Oct. and May, with most losses occurring during snowmelt. Antecedent conditions influenced tile drainage and P-exports. A drought in summer 2012 depleted hydrologic storage and significantly retarded tile flow during the fall wet-up, despite abundant rainfall. The speciation of P also differed seasonally and observed across all plots, where SRP represented a higher fraction of TP during winter thaw events than during rainfall events. NT and RT practices do not export more P than CT plots at our sites. *Keywords: Tile drainage, Pollution load, Tillage, Phosphorus, Best management practices.*

LANDON, M.E.[1], MURPHY, E.W.[2], AMOS, M.A.[1], SCHOFIELD, J.A.[1], and BLUME, L.J.[2], [1]CSC, 6361 Walker Lane, Suite 300, Alexandria, VA, 22310; [2]U.S. EPA Great Lakes National Program Office, 77 West Jackson Boulevard, Chicago, IL, 60622. **Navigating Change in a Long Term Monitoring Program.**

The U.S. EPA Great Lakes National Program Office (GLNPO) Great Lakes Fish Monitoring and Surveillance Program (GLFMSP) focuses on monitoring long term trends in contaminant concentrations in fish collected in the Great Lakes' open waters using top predator fish as biomonitors for select contaminants. Navigating change in a long term monitoring program like the GLFMSP, which depends on reliable and consistent quality data col-

lected annually, is challenging. How do you ensure the reliability, consistency, and quality of data when making a significant change, such as selecting a new laboratory to perform sample preparation and homogenization services after years of using the same laboratory? We will provide an example of a successful transition, explain procedures used to ensure data quality and consistency, discuss lessons learned, and offer tips on making the process as smooth as possible. *Keywords: Consistency, Monitoring, Quality, Fish, Data.*

LANG, G. and LESHKEVICH, G., NOAA/Great Lakes Environmental Research Laboratory, 4840 South State Road, Ann Arbor, MI, 48108. **Persistent Wind Fields Over the Great Lakes, 2006-2012.**

Hourly analyzed gridded wind fields over the Great Lakes produced by the Great Lakes Coastal Forecast System have been averaged for each year for years 2002 to 2013. Wind speeds are interpolated from hourly measurements made at buoys, CMAN stations, and shore stations. The observed winds were first normalized to 10m anemometer height and then converted from over-land to over-water where necessary, using a method described in Schwab and Morton (1984). These resultant winds were then mapped to the GLCFS bathymetric grids using a natural neighbor technique. Whole-lake, mean-annual wind speeds ranged from 5.6 to 7 m/s, with the strongest winds over lake Erie. In general, Lake Huron winds were the most variable, while Lake Ontario winds were least variable. Offshore winds tended to be greater than nearshore winds. *Keywords: Satellite technology, Wind fields, Remote sensing, Hydrodynamic model.*

LANGER, T.A., PANGLE, K., MURRY, B.A., and UZARSKI, D.G., Central Michigan University, Mount Pleasant, MI, 48859. **Beta Diversity, Spatiotemporal Structuring and Mechanisms Shaping Great Lake Coastal Wetland Fish and Macroinvertebrate Communities.**

At the community-landscape interface, beta diversity describes variation and patterns in biodiversity among sites. Insight into how biodiversity patterns are coupled with habitat conditions may depict mechanisms shaping diverse communities, ultimately informing effective management. Executing a site to basin wide spatiotemporal hierarchal assessment we explored diversity patterns and factors shaping Great Lake coastal wetland fish and macroinvertebrate assemblages from 2000-2012. We used beta indices and multivariate ordination techniques on each assemblage with efforts pooled to similar hierarchical extents for community based conclusions. Beta indices indicated strong species replacement structuring

across space and time with increasing beta diversity as scale localized. Multi-response permutation procedures suggested a significant spatial and temporal contribution to community differences. Correlations between ordinated assemblages and habitat characteristics suggested multiple scale-dependent factors, such as water depth and habitat type, associated to diversity patterns. With relatively unique communities across space and time, biodiversity oriented management should conserve all wetlands as biodiversity hotspots are not apparent and implications of climate and habitat alterations may alter current coastal communities. *Keywords: Biodiversity, Wetlands, Fish.*

LANTRY, B.F.[1], ADAMS, J.[2], CHRISTIE, G.C.[3], SCHANER, T.[4], BOWLBY, J.[4], KEIR, M.J.[5], LANTRY, J.R.[6], SULLIVAN, P.[7], BISHOP, D.[8], TRESKA, T.[9], and MORRISON, B.[7], [1]U. S. Geological Survey, Lake Ontario Biological Station, 17 Lake St., Oswego, NY, 13126; [2]U. S. Geological Survey, Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105; [3]Fisheries and Oceans Canada, Great Lakes Laboratory for Fisheries and Aquatic Sciences, 867 Lakeshore Rd., Burlington, ON, L7R 4A6; [4]Ontario Ministry of Natural Resources, Lake Ontario Management Unit, Glenora Fisheries Station, 41 Fish Hatchery Ln., R. R. #4, Picton, ON, KOK 2T0; [5]Environment Canada, Water Quality Monitoring and Surveillance, Ontario Science and Technology Branch, 867 Lakeshore Rd., P. O. Box 5050, Burlington, ON, L7R 4A6; [6]New York State Department of Environmental Conservation, Cape Vincent Fisheries Station, 541 East Broadway, P. O. Box 292, Cape Vincent, NY, 13618; [7]Fisheries and Oceans Canada, Sea Lamprey Control Centre, 1219 Queen St. East, Sault Ste. Marie, ON, P6A 2E5; [8]New York State Department of Environmental Conservation, 1285 Fisher Ave., P. O. Box 5170, Cortland, NY, 13045; [9]U. S. Fish and Wildlife Service on detail to the Great Lakes Fishery Commission, 2100 Commonwealth Blvd., Suite 100, Ann Arbor, MI, 48105. **Is the frequency of wounds observed on preferred and alternate hosts related to host and Sea Lamprey abundance for Lake Ontario?**

We examined how attack frequency by Sea Lampreys on fishes in Lake Ontario varied in response to Sea Lamprey abundance and preferred host abundance (Lake Trout > 432 mm). For this analysis we used two gill net assessment surveys, one angler creel survey, three salmonid spawning run datasets, one adult Sea Lamprey assessment, and a bottom trawl assessment of dead Lake Trout. The frequency of fresh Sea Lamprey wounds observed on Lake Trout from assessment surveys was strongly related to the frequency of Sea Lamprey attacks observed on salmon and trout from the creel survey and spawning migrations. Attack frequencies on all salmonids examined were related to the ratio between the abundances of adult Sea Lampreys and Lake Trout. Reanalysis of the susceptibility to Sea Lamprey attack

for Lake Trout strains stocked into Lake Ontario reaffirmed that Lake Superior strain were among the most and Seneca Lake strain among the least susceptible and that Lewis Lake strain were even more susceptible than Superior strain. Seasonal attack frequencies indicated that as the number of observed Sea Lamprey attacks decreased during June-September, the ratio of healing to fresh wounds also decreased. Simulation of the wound ratios indicated that increased lethality of attacks by growing Sea Lampreys contributed to this decline. *Keywords: Sea Lamprey, Lake trout, Lake Ontario, Invasive species.*

LAURENT, K.L.[1], FRIEDMAN, K.B.[2], KRANTZBERG, G.[3], SCAVIA, D.[4], and CREED, I.[1], [1]Department of Biology, Western University, 1151 Richmond St, London, ON, N6A 3K7; [2]University at Buffalo School of Architecture and Planning, Regional Institute, SUNY, 77 Goodell Street, Suite 302, Buffalo, NY, 14203; [3]Centre for Engineering and Public Policy, McMaster University, ETB 510, 1280 Main Street W., Hamilton, ON, L8S 4L7; [4]Graham Sustainability Institute, University of Michigan, 625 E. Liberty St., Ann Arbor, MI, 48104.
**Strategic tools to overcome policy barriers and move the Great Lakes-St. Lawrence River Basin closer to a "thriving and prosperous" future.**

The challenge of meeting the social, economic, and environmental policy needs of the Great Lakes-St. Lawrence River basin is shared among scholars, policy makers, and stakeholders at the local, state/provincial, federal, and bi-national levels. The Great Lakes Futures Project created a space for dialogue among stakeholders regarding the Basin's past, present, and future. The Project used scenario analysis to paint alternate futures and engage stakeholders in a discourse on how to move away from an undesirable future and toward a desired one. Here, we synthesize the results of the process that helped the community understand the challenges and barriers to more effective policy, provide a set of principles for guiding policy that can help overcome these challenges, break down barriers, and shape strategic policy formulation, program investment, and implementation. We then recommend broad policy directions, using the principles as a guide, to move the Basin toward one that thrives ecologically, socially, and economically. *Keywords: Transdisciplinary research, Scenario analysis, Political aspects.*

LEAL, K.A.[1], SPOELSTRA, J.[1,2], SENGER, N.[1], and SCHIFF, S.L.[1], [1]Department of Earth and Environmental Sciences, University of Waterloo, 200 University Avenue West, Waterloo, ON, N2G 3L1; [2]Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6.

**Stable Isotopes Reveal Sources of Groundwater Sulfate in an Agriculture-Dominated Watershed.**

Sulfur is an essential nutrient for plant growth and development. With decreasing rates of sulfur deposition, sulfur levels in soils are becoming depleted, leading farmers to turn to fertilizers as sulfur additives. As a part of a multi-year study, sulfate concentrations in groundwater in an agriculture-dominated watershed in Southwestern Ontario were found to range from below detection to 256 mg/L. Elevated concentrations of sulfate in groundwater can lead to the release of sediment bound phosphorus in riparian areas, which can cause eutrophication of surface waters. Stable isotope analysis was used to identify the potential sources of sulfate to the groundwater. At depth, $\delta^{34}S$ and $\delta^{18}O$ values were similar to those expected for denitrification and pyrite oxidation while other areas of the aquifer had isotope values closer to the isotopic composition of a commonly used fertilizer in the area, potassium magnesium sulfate. Results indicate various sources of sulfate across the aquifer and at depth. This study indicates that stable isotopic analysis used in conjunction with traditional geochemistry, can add valuable insight into sources and production pathways of sulfates in groundwater *Keywords: Agriculture, Isotope studies, Nutrients.*

LEBLANC, J.P. and CHOW-FRASER, P., McMaster University, 1280 Main St. W., Hamilton, ON, L8S 4K1. **Towards development of a habitat suitability index model for young-of-the-year muskellunge in Georgian Bay.**

Previous literature has shown that when habitat for a particular life stage is limited, that life stage and its associated habitat represent a limiting bottleneck for the adult population. This situation is especially difficult to diagnose in long-lived populations when management efforts have successfully protected the spawning adults, as in the case of muskies in Georgian Bay, whose adults reach trophy size largely because of restrictive harvest regulations and voluntary catch and release practices. But even when these adults spawn, the population will eventually fail if suitable habitat for young-of the-year (YOY) is limited or absent. Unfortunately, very little information exists that can help managers identify suitable nursery habitat in Georgian Bay. This study was initiated to compare habitat features in two regions of Georgian Bay, one where YOY muskies had been caught over 30 years ago but where they can no longer be found (Severn Sound) and another where YOY are currently prevalent (Beaverstone Bay). We are able to statistically discriminate between habitats that are associated with and without YOY using biotic and abiotic variables. Our ultimate goal is to use this information to build a habitat suitability model that can be applied throughout Georgian Bay to identify and quantify critical habitat for the muskellunge *Keywords: Nursery habitat, Georgian Bay, Muskellunge, Coastal wetlands, Populations.*

LEGER, W.P., Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **Building a Collaborative Adaptive Management Approach Across the Great Lakes-St. Lawrence River System.**

The most recent International Joint Commission studies on the Regulation Plans for managing Great Lakes water levels including the International Upper Great Lakes Study and the Lake Ontario-St. Lawrence River Study, concluded that adaptive management (AM) is the best way to address uncertainties including those associated with climate change and the potential for extreme water levels. Other Great Lakes efforts such as the Great Lakes Water Quality Agreement 2012, the Great Lakes Restoration Initiative, and the Sustainable Water Resources Agreement and Compact have all called for an AM approach. AM requires on-going assessment of how the system is changing, how ecosystems are evolving in response to observed conditions and management actions, and the development of science-based adaptive strategies to guide management actions and ecosystem restoration responses. This presentation will examine a proposed AM framework representing a collaborative approach to gather and share critical information over time, assess the information with state-of-the art tools, and measure our collective success in managing impacts. While the focus will be on AM for addressing extreme water levels, emphasis will also be placed on the potential for collaboration and overlap for supporting AM efforts across various Great Lakes initiatives. *Keywords: Water level fluctuations, Adaptive Management, Great Lakes basin, Climate change, Monitoring.*

LEHNHERR, I.[1], ST.LOUIS, V.L.[2], MUIR, D.C.G.[3], EMMERTON, C.E.[2], GARDNER, A.S.[4], LAMOUREUX, S.F.[5], MICHELUTTI, N.[6], SCHIFF, S.L.[1], SHARP, M.[7], SMOL, J.P.[6], and ST.PIERRE, K.A.[2], [1]Department of Earth and Environmental Sciences, University of Waterloo, Waterloo, ON, N2L 3G1; [2]Dept. of Biological Sciences, University of Alberta, Edmonton, AB; [3]Canada Centre for Inland Waters, Environment Canada, Burlington, ON; [4]Graduate School of Geography, Clark University, Worcester, MA; [5]Dept. of Geography, Queen's University, Kingston, ON; [6]Dept. of Biology, Queen's University, Kingston, ON; [7]Dept. of Earth and Atmospheric Sciecnes, University of Alberta, Edmonton, AB. **Recent Climate Change Impacts on Lake Hazen (the largest lake north of the Arctic Circle) and its Watershed.**

The Arctic is undergoing rapid climate change as demonstrated by increasing air temperatures, changes in precipitation patterns, permafrost degradation, and decreased sea-ice extent and thickness. However, the impacts of these changes on Arctic lakes, especially larger lakes, are not well understood. Lake Hazen is the largest lake (by volume) north of the Arctic Circle and integrates a large watershed that is extensively glaciated. Because of its large size, Lake Hazen may be less sensitive, or slower to respond, to climate change compared to smaller lakes. We will present data on various physical, chemical and biological parameters, spanning ~20 years for observational data and ~200 years for paleolimnological data, to determine how, and to what extent, climate change is impacting Lake Hazen and its watershed. In addition to measured temporal records of water-level, outflow discharge, lake ice-cover, and catchment soil temperatures, output from numerical models of glacier mass-balances and snowmelt will also be discussed. Finally, the temporal trends in the above variable will be used to provide context to paleolimnological studies on sedimentation rates, sediment geochemistry and algal microfossils, with the purpose of identifying how physical changes are impacting in-lake biogeochemical processes and biological communities. *Keywords: Arctic, Climate change, Biogeochemistry.*

LEISTI, K.E.[1], COURT, A.[2], DOKA, S.E.[1], and THEYSMEYER, T.[2], [1]Fisheries and Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6; [2]Royal Botanical Gardens, 680 Plains Road West, Burlington, ON, L7T 4H4. **Aquatic vegetation trends and targets in Hamilton Harbour and Cootes Paradise.**

Historically, Hamilton Harbour had a complex wetland system estimated at 500 hectares that once supported both a coldwater and a warmwater fishery. Industrialization and population growth had a dramatic impact on the Harbour and infilling of the south shore began in 1862. By 1959, the harbour had lost 22 percent of the open water area and 85 percent of the original vegetated shoreline. The remaining areas experienced a decline in both the emergent and submergent vegetation due to multiple stressors such as reduced light penetration, siltation, increased water levels and disturbance by carp. In 1985, Hamilton Harbour was declared an Area of Concern (AOC) by the International Joint Commission due in part to the loss of aquatic vegetated habitat. In response to the AOC listing, the first DFO submerged aquatic vegetation (SAV) survey of Hamilton Harbour was conducted in 1986 and additional surveys followed in 1992 to 1996, 2006 and again in 2012. Delisting objectives for the Harbour were developed that included metrics for both the extent and the quality of emergent and submergent vegetation. The extent and density of vegetation has improved in Hamilton Harbour and somewhat in Cootes but recent increases in algae and lower water levels may have shifted the vegetation community. *Keywords: Hamilton Harbour, Trends, Vegetation.*

LENTERS, J.D.[1], SPENCE, C.[2], BLANKEN, P.D.[3], GRONEWOLD, A.D.[4], KERKEZ, B.[5], FROELICH, N.J.[6], PAIGE, K.[7], and SLAWECKI, T.A.D.[1], [1]LimnoTech, 501 Avis Drive, Ann Arbor, MI, 48108; [2]National Hydrology Research Centre, Environment Canada, Saskatoon, SK; [3]Department of Geography, University of Colorado-Boulder, Boulder, CO; [4]NOAA-GLERL, Ann Arbor, MI; [5]Department of Civil and Environmental Engineering, University of Michigan, Ann Arbor, MI; [6]Earth, Environmental, and Geographical Sciences Department, Northern Michigan University, Marquette, MI; [7]Great Lakes Observing System, Ann Arbor, MI. **Great Lakes evaporation: "Measuring to manage" during a time of transition.**

Over-lake evaporation represents one of the most critical but sparsely measured components of the Great Lakes water balance. Yet despite the scarcity of observation sites, new evaporation measurements from this growing network of stations are coming at an appropriate time to help inform predictive models of Great Lakes evaporation. Such models have shown evidence of a recent decadal-scale transition to higher evaporation rates on the Great Lakes, particularly during summer. These predicted increases in evaporation have been borne out in the recent observational datasets, manifested as an earlier start to the summer evaporation season. We present Lake Superior as an illustration of an "ecosystem in transition" following the warm El Niño winter of 1997/98 - an event from which the lake has yet to show a full recovery. Observations of enhanced summer evaporation rates on the Great Lakes are found to typically occur in concert with warmer water temperatures, and are generally preceded by winters with low ice cover. Interestingly, however, the new observations also show important feedbacks of autumn and winter evaporation on ice cover itself, leading to potentially offsetting influences. This improved understanding of the science of large-lake evaporation is now being used to help inform decision making on the Great Lakes. *Keywords: Atmosphere-lake interaction, Climate change, Hydrologic budget.*

LEONARD, J.B.K. and CROSS, R., Biology Department, Northern Michigan University, Marquette, MI, 49855. **Movement-related life history variation in brook trout (*Salvelinus fontinalis*) in Lake Superior tributary streams.**

Life-history variation in salmonid fishes related to movement behavior represents intraspecific biodiversity important for species resiliency and ecosystem functioning. We

used RFID/PIT telemetry in two Lake Superior tributaries to assess movement expressed in brook trout (*Salvelinus fontinalis*). Using a dataset of 650 fish tagged over four years, we detected 9-44% emigration from the streams, which likely represented the migratory (coaster) life history. Coasting behavior was not related to fish size or condition, but was predicted by a tagging location nearer to the mouth of the stream. Of the 506 fish (78%) that remained within the stream following tagging, the majority (55-60%) remained stationed close to their tagging site; however, the remainder exhibited other types of movement behavior ranging from unidirectional up- or downstream movements (20-40%) to nomadic roving (8-10%) within the study section. Mobile fish occurred throughout the streams, with a trend toward greater numbers of nomads tagged near the mouth; there was no relationship between size/condition and likelihood of mobile behavior. The proportions of fluvial movement behaviors were similar between streams and suggest more variability in movement behavior than is suggested by the migrant/resident dichotomy typically attributed to salmonids. *Keywords: Fish behavior, Life history studies, Trout.*

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

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. New products include chlorophyll, DOC, suspended mineral, and HABs and new data sets such as Great Lakes Inherent Optical Properties geospatial database, 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, Data storage and retrieval.*

LESHT, B.M.[1], BARBIERO, R.P.[2], WARREN, G.J.[3], and WARNER, D.M.[4], [1]CSC and University of Illinois at Chicago, 845 W. Taylor St., Chicago, IL, 60607; [2]CSC, 1359 W. Elmdale, Suite 2, Chicago, IL, 60660; [3]USEPA Great Lakes National Program Office, 77 W. Jackson Blvd, Chicago, IL, 60604; [4]USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105. **Temporal and Spatial Scales of Change in Great Lakes Chlorophyll Concentration Inferred from Satellite Observations: 1998-2013.**

Much of what we know about lake-scale patterns of Great Lakes productivity is based on field observations that are limited in both time and space. Usually averaged over several-year periods, analyses of these observations have shown that the lakes have undergone significant changes over the recent decades, with apparent reductions in primary production and increases in clarity most notable. In this study we use satellite observations to look at detailed changes (in both space and time) in chlorophyll concentrations in all five lakes. Using daily fields estimated with an image compositing algorithm we calculate temporal and spatial anomalies (relative to long term averages) and integrate these anomalies over different time scales to explore how the detailed patterns of production (using chlorophyll concentration as a surrogate) have changed over the period of record (1998-2013). *Keywords: Distribution patterns, Remote sensing, Phytoplankton, Productivity.*

LI, J.[1], MOLOT, L.A.[1], PALMER, M.E.[2], WINTER, J.G.[2], YOUNG, J.D.[2], and STAINSBY, E.[2], [1]Department of Biology, York University, Toronto, ON, M3J 1P3; [2]Ontario Ministry of the Environment, 125 Resources Road, Toronto, ON, M9P 3V6. **Cumulative Impact of Phosphorus Loading Reductions, Invasive Species and Climate Change on Minimum Volume-Weighted Hypolimnetic Dissolved Oxygen in Lake Simcoe, 1980-2012.**

Lake Simcoe has been affected since 1980 by multiple drivers especially by reductions in phosphorus (P) loading, climate change and invasive species such as zebra mussels which became firmly established after 1996. We examined the cumulative impact of these drivers on the ice-free minimum volume-weighted hypolimnetic dissolved oxygen concentration (VWHDO_min) below 18 m at station K42 in Kempenfelt Bay. DO depletion began in early spring when thermal stratification was observable but weak and continued throughout the ice-free season until cooling sufficiently lowered stability. There was good agreement between predicted and observed minimum VWHDO using the formula: Predicted VWH-

DO_min = VWHDO_init - DR * L (where VWHDO_init is the VWHDO at the beginning of the DO depletion period, DR (depletion rate) is the slope of VWHDO vs time and L is the length of the depletion period). In 1996-2012 compared to 1980-1990, mean VWHDO_init was 2.4 mg/L higher and the DR was slightly (3%) lower but the duration, L, was 21 days (27%) longer. We calculate that the mean VWHDO_min during 1996-2012 would have been 1.8 mg/L instead of the 4.4 mg/L observed if the VWHDO_init and DR remained at mean 1980-1990 levels. Hence, climate change may have offset improvements in VWHDO_min generated by P controls and invasive species by lengthening L. *Keywords: Lake Simcoe, Multiple stressors, Oxygen, Invasive species, Climate change, Phosphorus.*

LI, J.Z., CHOWDHURY, M., and WELLS, M.G., University of Toronto Scarborough, Department of Physical and Environmental Sciences, Toronto, ON. **Determing the influence of shifts in wind speed and thermal stratification upon mixing regimes in Lake Simcoe.**

There have been shifts in the thermal stratification and wind regimes in Lake Simcoe over the last 30 years, which may have lead to changes in vertical mixing rates of oxygen within the water column. We will analyze data of water temperature profiles and surface wind data, that were collected from 1980-2013 to monitor the impact of climate change on physical processes within Lake Simcoe. Previous descriptions of stratification in Lake Simcoe using the Schmidt Stability Index have shown clearly that there is an increase in both the length and strength of the summer stratification. We will use the dimensionless Lake Number (the ratio of Schmidt's Stability to the wind energy) to determine if there has been significant changes in the intensity of turbulent mixing in this lake. While mean wind speeds have decreased over the last 3 decades, it appears that the frequency and magnitude of storm events has actually increased, so that there may be the possibility that seasonally averaged mixing rates have increased over this 30 year period. We will use the statistics of when the Lake Number is less than unity to gain more insight about the physical phenomenon within Lake Simcoe. *Keywords: Climate change, Lake Simcoe, Water currents.*

LI, S.[1], MCCARTNEY, J.[2], PAWLUCZYK, O.[2], FLANNERY, J.[3], VERBUST, M.[1], FRASER, S.[1], DÜRR, H.[1], MITCHELL, K.[1], DRIEDGER, A.[1], and VAN CAPPELLEN, P.[1], [1]Ecohydrology Research Group, Earth Science Department, University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L 3G1; [2]P&P Optica, 680-A Davenport Road, Waterloo, ON, N2L 2C3; [3]Physics Department, University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L 3G1. **Development and verification of a novel field equipment for detection of plastic debris in surface waters and coastal environments.**

Plastic debris in surface waters/coastal environments negatively impact aquatic habitats, wildlife and navigation, determine economic losses and threaten human health and safety. To our knowledge there are currently no available infrared sensors for in-field detection and characterization of plastic debris in natural environments. To meet this challenge a research collaboration was established between the Ecohydrology Research Group (ERG) at the University of Waterloo and P&P Optica (P&P), to develop and verify a proof-of-concept spectral infrared system. Staff at P&P designed, built and optimized a novel near infrared(NIR) reflectance spectral system. ERG researchers collected plastic samples from Great Lake beaches and produced some artificially aged plastics samples using controlled light exposure, temperature, and mechanical abrasion in a laboratory setting. An analytical comparison study has been performed using the new system and a regular Raman Spectroscope at the University of Waterloo. Results leads to conclude that both the newly developed system and Raman can be successfully used for in-field detection and identification of many plastics, and that Raman seems to be more suitable for use with wet samples. Further research on the application of both NIR and Raman for plastic detection in natural environments is needed.
*Keywords: Environmental contaminants, Water quality, Lake management.*

LIANG, A.[1], QUAZI, S.[1], CHESNYK, A.[1], PALIY, R.[1], MUGALINGAM, S.[2], GEATER, K.[3], WATSON, S.B.[4], and DITTRICH, M.[1], [1]Department of Physical and Environmental Sciences, University of Toronto Scarborough, 1265 Military Trail, Toronto, ON, M1C 1A4; [2]Lower Trent Conservation, 714 Murray Street, Trenton, ON, K8V 5P4; [3]Environment Canada, Great Lakes Areas of Concern, 4905 Dufferin Street, Toronto, ON, M3H 5T4; [4]Environment Canada, Watershed Hydrology and Ecology Research Division, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **Linking phosphorus binding forms and internal loading in Bay of Quinte: insights from a field study.**

High Phosphorus (P) loading has been linked to excessive productivity and algal blooms in the Bay of Quinte which was designated as an Area of Concern (AOC) in 1986. High phosphorus concentrations reflect not only point sources and agricultural and urban runoff, but also P released from sediment into the water column through processes controlled by physical, chemical and biological conditions. Although there is evidence that P release from sediments supports those cyanobacteria, we know very little about P release from sediments of Bay of Quinte and its impact on cyanobacterial blooms. This study aims to understand the P release from the sediments thereby linking them to the cyanobacterial bloom.

Sediment cores from three stations (Hay Bay, Bellevile, Napanee) were collected. Oxygen, pH and redox potential were monitored by microsensors; porewater and sediment solid matter were analyzed for nutrient and metals content and a sequential extraction method was used to extract the P binding forms. The P fluxes have been calculated and related to geochemical conditions and P binding forms in sediments. Results indicated that the total P for all the three stations was close to 1 mg/gm with Station B having the highest TP concentration. The P binding forms and their impact on P internal loading have been analyzed. *Keywords: Sediment control, Phosphorus, Bay of Quinte.*

LIDDLE, G.E., LA ROSE, J., ADKINSON, A., and DOLSON, R., Southern Biodiversity and Monitoring Unit, Ontario Ministry of Natural Resources, 26465 York Rd 18, Sutton West, ON, L0E 1R0. **Long term shifts in the Lake Simcoe Recreational Fishery as Revealed by 50 Years of Intensive Monitoring.**

With a multispecies recreational fishery that spans all seasons, Lake Simcoe is one of Ontario's most intensively fished inland lakes. The Ontario Ministry of Natural Resources has monitored this recreational fishery for over five decades using roving creel surveys that follow a stratified, random design. Over the past 50 years these surveys have documented long term trends and short term changes in summer and winter fishing on Lake Simcoe. Winter fishing effort has accounted for up to 75% of angling on Lake Simcoe with the majority of anglers targeting three species: lake whitefish, lake trout and yellow perch. Summer anglers target a wider array of species including smallmouth bass, yellow perch, lake trout, northern pike and lake whitefish; however, summer fishing effort appears to have declined since the mid-1980s. Creel surveys have revealed marked changes in the catch of key species, including recent declines in winter lake trout and summer smallmouth bass catches as well as long term increases in yellow perch catch. Fisheries management on Lake Simcoe has for decades relied on creel survey data to reveal emerging environmental and fish community issues as well as to evaluate the effect of management actions. *Keywords: Fisheries, Fish populations, Lake Simcoe.*

LIDDLE, G.E., CHALLICE, A.R., and STANLEY, E., Ontario Ministry of Natural Resources - Aurora District, 50 Bloomington Rd W, Aurora, ON, L4G 0L8. **An Overview of the Lake Simcoe Muskellunge Restoration Project.**

The muskellunge (*Esox masquinongy*) is native to Lake Simcoe, Ontario and supported a commercial fishery and sport fishery in the late 1800's and early 1900's, respectively. After significant overharvest, habitat loss and ecological change, the Lake Simcoe population of muskellunge was significantly reduced by the 1930's. The sport fishery in both Lake Simcoe and Lake Couchiching was closed in 2005. Feasibility and habitat inventory studies determined that restoration of the Lake Simcoe muskellunge population is a realistic management objective. The goal of the Lake Simcoe Muskellunge Restoration Project is to restore a self-sustaining muskellunge population to Lake Simcoe through a long-term restoration project including habitat enhancement and stocking efforts. Proposed 2014 works are nearshore, targeting critical spawning/nursery areas and will benefit the nearshore fish communities, with additional benefits to water quality. Many challenges are identified, including choosing enhancement sites, future habitat protection, logistical concerns considering Lake Simcoe is a large inland lake, biological risk, and defining program success. However, these challenges can be addressed with support from the strong partnerships and significant funding commitments that have guided this long-term restoration project to date. *Keywords: Fish management, Muskellunge, Lake Simcoe, Lake Simcoe south-eastern Georgian Bay Clean-up Fund, Assessments, Habitat enhancement.*

LINLEY, R.D., CURRIE, W.J.S., GERLOFSMA, J., and BAILEY, S.A., Fisheries and Oceans Canada, 867 Lakeshore Rd., Burlington, ON, L7R 4A6. **Application of Coastal Oceanic Sensor Arrays in the Hamilton Harbour Area of Concern.**

Hamilton Harbour is a designated Area of Concern within Lake Ontario that has experienced a multitude of alterations due to industrial and urban development as well as non-native species introductions resulting in substantial effects throughout aquatic community. Monitoring for biological, physical and chemical changes in the harbour encounters the classic sampling trade-off between spatial and temporal representativeness. Currently, sampling occurs bi-weekly at a small number of stations intending to be representative of the Harbour as a whole. In this study we will examine the harbour in a spatially extensive analysis throughout a season but with a reduced focus on the species level, using an Acrobat tow body with a Laser Optical Plankton Counter (LOPC), Conductivity, Temperature, Depth, Turbidity and Chlorophyll sensors and a YSI EXO 2 on board. We gather extensive simultaneous spatial data on limnetic in-situ plankton size distributions and physical/chemical measures using sawtooth epilimnetic and tow-yo transects to cover the entire harbour in a short period of time. The instrumentation setup and its application in other aquatic environments will be discussed. *Keywords: Ecosystems, Spatial monitoring, Plankton, Area of concern, Hamilton Harbour.*

LIOU, L.[1], SHUCHMAN, R.A.[2], GREB, S.[3], LESHKEVICH, G.[4], BRATTON, J.[4], READ, J.[5], LEKKI, J.[1], BROOKS, C.N.[2], and GRIMM, A.G.[2], [1]NASA Glenn Research Center, 21000 Brookpark Rd., Cleveland, OH, 44135; [2]Michigan Tech Research Institute, 3600 Green Ct., Ste. 100, Ann Arbor, MI, 48105; [3]Wisconsin DNR, 101 S Webster Street, Madison, WI, 53707; [4]NOAA/GLERL, 4840 S. State Rd., Ann Arbor, MI, 48108; [5]GLOS, 229 Nickels Arcade, Ann Arbor, MI, 48104. **Initial Results from the Workshop on Developing a Great Lakes Remote Sensing Community.**

The state of the science of remote sensing of inland waters, particularly the Great Lakes, has progressed significantly over the past decade in step with satellite infrastructure, freshwater optical algorithms, radar and lidar data, and increasingly capable unmanned aerial vehicles (UAVs) and autonomous underwater vehicles (AUVs). However, despite the above and the current efforts to coordinate research and facilitate data sharing, the evolution of a remote sensing community in the Great Lakes is still in its early stages.This presentation communicates the results from two workshops on remote sensing of inland water quality focused on the Great Lakes. These workshops aimed to accelerate the formation of this community and further the advancement of remote sensing of water quality. Attendees included data generators and data users from the federal and state agencies, academia, water monitoring programs, tribal and other stakeholder organizations, regulatory bodies, and international organizations. The workshop will generate a summary white paper with recommendations for consideration by the 2017 NASA Earth Science Decadal Survey. The workshops are associated with an interactive website to provide access to previous and current workshop documents and serve as a platform for collaboration on a continuing basis. *Keywords: Great Lakes basin, Data sharing, Remote sensing.*

LIU, W.[1], TROY, C.D.[1], HÖÖK, T.O.[2], and BUNNELL, D.B.[3], [1]School of Civil Engineering, Purdue University, West Lafayette, IN, 47907; [2]Department of Forestry and Natural Resources, Purdue University, West Lafayette, IN, 47907; [3]U.S. Geological Survey, Great Lakes Science Center, Ann Arbor, MI, 48105. **Inter-annual Variability of Physical Processes in Lake Michigan.**

Inter-annual variability of physical processes may strongly mediate chemical and biological dynamics in the Great Lakes, including Lake Michigan. We quantified annual physical conditions in Lake Michigan for the period of 1980-2012, based on air and water temperature, river discharge, wind, ice cover, precipitation, lake circulation, lake thermal pattern, upwelling, turbidity, etc. Specifically, we analyzed two types of data: historical field data and hydrodynamic model output. The modeling was conducted using Purdue's hydrodynamic

model of Lake Michigan, which is a modified version of the Stanford University's environmental fluid mechanics solver SUNTANS. Annual physical indices and regime measures at both lake-wide and sub-region scales were produced to evaluate how physical processes co-vary. Ultimately, these indices will contribute to studies of fish recruitment and other biotic factors in Lake Michigan and other Great Lakes. *Keywords: Lake Michigan, Hydrodynamic model, Climatic data.*

LIZNICK, K.M.S. and BRANFIREUN, B.A., Western University, 1151 Richmond Street, London, ON, N6A 3K7. **Total and Methyl Mercury in Lake Erie Sediments, Water and Seston: Toward Identifying the Cause of Recent Increases in Fish Mercury.**

Long-term monitoring has shown that despite a decline in regional atmospheric mercury (Hg) emissions since the 1970s, there is an increasing trend in Hg levels in predatory fish of Lake Erie. The uptake of Hg in aquatic ecosystems may be controlled by factors, such as water temperature, oxygen levels, and pH, that vary among and within lakes. They influence the conversion of inorganic Hg to the more biologically harmful and bioaccumulaing methylated form (MeHg). A current, complete sampling of THg and MeHg over space and time is needed to establish the background environmental levels in Lake Erie, which is required to analyze Hg trends in biota. Total Hg (THg) and MeHg concentrations were measured in Lake Erie water, sediment and seston collected spring to fall, 2012. THg and MeHg in water and sediment follow the same spatial gradient, with concentrations decreasing from West to East, however modern sediment concentrations have not decreased significantly from historical ones. Mean seasonal THg concentrations in the West and Central basins are somewhat comparable at 49.69 and 35.85 ng/g respectively, however, the Central basin mean MeHg concentration is nearly twice that of the West, at 12.20 versus 6.18 ng/g. These data will be used to analyze Hg patterns in prey species, and further interpret trends in fish concentrations. *Keywords: Bioaccumulation, Lake Erie, Mercury.*

LOFGREN, B.M., NOAA Great Lakes Env Res Lab, 4840 S. State Rd., Ann Arbor, MI, 48108. **Atmospheric and Water Budget Projections from a Regional Modeling System.**

The impacts of climate change on the Great Lakes region are likely to be manifold, and at the same time, carry significant levels of uncertainty. Among the key factors are lake water temperature, governed by surface heat exchange, vertical mixing, and lake dynamics, and lake water levels, governed by the balance between precipitation and evapotranspiration in both the lake and land portions of the basin. The Coupled Hydrosphere-Atmosphere Research Model (CHARM), an atmosphere-lake-land model of the Great Lakes region, provides a testbed for generating projections of climatic and hydrologic results of climate change, as well as for pulling apart some of the processes that underlie those projections. We will examine CHARM's projections of water budgets and air and water temperatures, along with the exchanges of heat, wind, and moisture that drive these more recognized end products. *Keywords: Climate change, Model studies, Hydrologic budget.*

LONG, A.M. and SHORT, S.M., Department of Ecology and Evolutionary Biology, 25 Wilcocks Street, Toronto, ON, M5S 3B2. **Experimental determination of algal virus decay in a freshwater pond.**

Algal viruses may exert top-down control of aquatic primary production. Obtaining knowledge of virus ecology is critical to understanding how viruses influence algal growth and mortality. With the goal to establish a proxy for culture-free estimates of virus decay, and to estimate decay rates for two cultivated algal viruses, loss of infectivity over time (estimated via viral lysis experiments) was related to loss of viral DNA (estimated via quantitative PCR, or qPCR). Initial experiments using UV light to destroy viruses infecting the green algae *Chlorella* demonstrated the relationship between loss of virus DNA and loss of infectivity (0.76 $r^2$). Additionally, incubation experiments were conducted to track the decay of viruses over time in a freshwater pond. Known quantities of two algal viruses were spiked into pond water samples and were incubated *in situ* in polycarbonate bottles for times ranging from hours to weeks. Our results suggest that qPCR can be used as proxy to estimate virus decay and will allow us to estimate decay rates for the majority of aquatic viruses, those that have not yet been isolated. Moreover, the mean lifetimes for the two algal viruses were relatively short (3.73 and 4.46 days) reinforcing questions about their environmental persistence. *Keywords: Phytoplankton, Viruses, Algae, Decay, Microbiological studies.*

LONG, T.L.[1], WELLEN, C.C.[2], ARHONDITSIS, G.B.[3], and BOYD, D.[1], [1]Ontario Ministry of the Environment, 125 Resources Road, Toronto, ON, M9P 3V6; [2]McMaster University, 1280 Main Street West, Hamilton, ON, L8S 4L8; [3]University of Toronto, 1265 Military Trail, Toronto, ON, M1C 1A4. **Winter nutrient dynamics in the urban and agricultural watersheds of Hamilton Harbour, Ontario.**

Between July 2010 and May 2012, the four urban and agricultural tributaries to Hamilton Harbour, Ontario, Canada were sampled during 87 separate 24-hour periods, with a major focus on winter and high flow events. Samples were analyzed for a suite of nutrients and concentration trends with season were examined. TP concentrations generally did not demonstrate differences among seasons; however, large differences in TP magnitude and timing of delivery were observed between the two winters monitored, reflecting the contrasting inter-annual weather conditions in terms of temperature and precipitation patterns. Nitrate and phosphate concentrations demonstrated seasonal variability, with elevated concentrations observed during the fall and/or winter period, except in the primarily agricultural watershed where summer concentrations were higher. During the unseasonably cold winter of 2010-2011, ammonia and nitrate concentrations in some watersheds increased sharply and continuously until spring freshet, a seasonal phenomenon not observed during the unseasonably warm winter of 2011-2012. As nutrient concentrations are often higher during winter and demonstrate trends not observed during other more-characterized seasons, use of summer sampling to generate annual trends may result in erroneous conclusions. *Keywords: Hamilton Harbour, Seasonality, Watersheds, Nutrients.*

LOUGHNER, J.L.[1], GALAROWICZ, T.L.[1], MURRY, B.A.[1], and JOHNSON, J.E.[2], [1]Central Michigan University, Mount Pleasant, MI, 48859; [2]MI - DNR Alpena Fisheries Research Station, 160 E. Fletcher Street, Alpena, MI, 49707. **Lake Huron Beach Fish Assemblages: Temporal and Habitat Differences.**

Lake Huron has undergone dramatic shifts in fish community composition as a result of invasive species introductions and food web changes. In particular, Zebra Mussels and Round Gobies have greatly impacted near-shore fish communities. Our objective was to assess near-shore fish communities of western Lake Huron and compare species composition post invasion to species composition in 1993, prior to the invasion of Zebra Mussels and Round Gobies. Beach fish communities were sampled by nighttime beach seining during spring and summer 2012 in the western basin of Lake Huron along the Michigan shoreline. Our results show that overall, the nearshore beach fish assemblage species composition of 1993 is different from 2012. There is a reduced number of species present in 2012, and the composition of species has changed dramatically from 1993. The species composition has shifted from an Alewife, Salmonid and Smelt dominated community to a Round Goby, Cyprinid, and Percid dominated community. The observed shift in species composition is largely due to the introduction of invasive species; however, anthropogenic impacts such as shoreline modifications and habitat alterations are also likely to be contributing factors. *Keywords: Comparison studies, Nearshore Assemblages, Lake Huron, Exotic species.*

LOVELACE, R.P., Queen's University, Kingston, ON, K7L 3N6. **Learning to be human in environments where we belong.**

600 years of colonial economics and resettlement have dominated this planet's people and environments. While intellectual work in the last 100 years has made important theoretical and technological advances, there is a great divide between those who possess true ecological knowledge, living accordingly and those who postulate remedial actions. There is a great need to bridge this gap. Complementary lifeways, which balance cognitive, intuitive, emotional and physical realities can be learned and used to inform both scientific and artistic enquiry as well as maintaining eco-economic stability within distinct bio-regions. However, societal change does not happen without transition. This research looks at where we need to be as ecologically aware societies with stable economies but, most importantly for the contemporary "us", pathways to get there. It is the transition phases of adaptation, which are most perilous. They require, stepping back, exercising options, maintaining security, learning from mistakes and celebrating existence in a dynamic universe. Education for social and cultural change is explored through the processes of re-indigenization - learning to be human in environments where we belong. *Keywords: Aboriginal, Commons Devlopment, Education, Great Lakes basin.*

LUNDQUIST, D.C. and BAIER, R.E., State University of New York at Buffalo, Room 110 Parker Hall, Buffalo, NY, 14214. **Ballast Biofilm Challenges: Cleaning and Conversion.**

Although provisions are being made for improved reduction, or even elimination, of aquatic nuisance species from ballast water of ships entering or circulating within the Great Lakes system, no such provisions are yet made for the challenging task of removal and remediation of the biofilms spontaneously formed and remaining on the tank walls and sediments. Using a liquid spray system and surface-chemical principles first espoused by the US Navy, a surface-active displacement solution (SADS)is proposed to remove the remnant biofilm in these tanks and to prepare it as a useful specialty product to lessen total costs. At a single shore facility, visited by the average of more than 100 Great Lakes carriers each year for biofilm (slime) removal by SADS, specialty polymer bricks could be prepared in automatically sterile form as a building material, for instance. SADS are basically low-stability emulsions of butanol and an amphiphilic surfactant in water; butanol is an increasingly available byproduct of agriculture and the gentle betaine surfactant is used in baby products. About 80% of the SADS is recyclable for the next use. Aiding the reduction and cleaning of ballast tank wall biofilms would be the selection of corrosion-limiting, ductile "easy-release" coatings that would replace fouling-prone anti-corrosion paints now used. *Keywords: Cleanup, Biofilm, Ballast.*

LUPI, F., Michigan State University, East Lansing, MI, 48824. **Economic Benefits of Great Lakes Beach Recreation.**

With over 600 public beaches, beach visits are among the most popular recreational uses of the Great Lakes. Great Lakes beaches face threats and stresses from many sources, such as nuisance algae, closures due to E.coli, and development. Although information on economic benefits of healthy beaches can be used to improve management, there are almost no published studies of the value a day at a Great Lakes beach (an exception is Murray et al 2001). We conducted a survey of 30,000 Michigan residents to identify beachgoers and collect information on all Great Lake beach visits during the summer of 2011. Using the data on trip destinations, we estimated a spatially and temporally explicit economic demand model that forecasts Great Lake beach trips to over 450 public beaches in Michigan's Lower Peninsula. Beach visits depend significantly on economic factors such as the travel cost from a person's home to a particular beach, as well as on environmental factors such as the water temperature and the history of beach closures at a site. The economic demand model is used to generate contemporary estimates of the economic value of a beach day as well as economic benefits associates with water quality improvements. *Keywords: Beaches, Economic evaluation, Economic impact.*

LYANDRES, O.[1], EDDOWES, D.[2], CROSS, J.[1], DRAG, N.[1], and NEVILLE, S.[1], [1]Alliance for Great Lakes, 150 N. Michigan Ave. 700, Chicago, IL, 60601; [2]Earthwatch Institute, 114 Western Ave., Boston, MA, 02134. **Great Lakes Stewardship - A Model for Effective Employee Engagement in a Citizen Science Program.**

To address global and local freshwater challenges, there is a need to engage new audiences in stewardship. This project engaged corporate employees to become Citizen Science Leaders (CSLs) in Chicago, IL and Buffalo, NY. At each location, employees were trained to collect data on litter, water quality, beach surveys, and land use. During the training, the CSLs were also given information on regional and global water issues to encourage behavior changes to improve water quality. The program includes web-based data collection infrastructure and an online forum for CSLs, program coordinators, and researchers to interact. Furthermore communication to broader groups of employees featured the CSLs through webinars. The program also provides access to special monitoring and restoration events. In

2013, 80 CSLs were trained in Buffalo and Chicago and have collectively generated over 30 datasets. Preliminary findings suggest that there are differences in litter distribution between sites. These datasets can potentially inform water resource management plans both locally and globally. A broader focus on outreach, outside of the usual audiences, in particular with corporate employees who value their companies' emphasis on sustainability has the potential to foster commitment to stewardship of one of world's most valuable resources. *Keywords: Citizen science, Beach health, Outreach, Debris, Public participation.*

LYNCH, A.J.[1], TAYLOR, W.W.[1], BEARD, T.G.[2], and LOFGREN, B.M.[3], [1]Center for Systems Integration and Sustainability, Dept. of Fisheries & Wildlife, Michigan State U., 1405 S. Harrison Road, Suite 115 Manly Miles Bldg., East Lansing, MI, 48823; [2]National Climate Change and Wildlife Science Center, U.S. Geological Survey, 12201 Sunrise Valley Drive, MS 400, Reston, VA, 20192; [3]Great Lakes Environmental Research Laboratory, National Oceanic and Atmospheric Administration, 4840 S. State Road, Ann Arbor, MI, 48108. **The Projected Influence of Climate Change on Lake Whitefish (*Coregonus clupeaformis*) Recruitment in the 1836 Treaty Waters of Lakes Huron, Michigan, and Superior.**

Lake Whitefish (*Coregonus clupeaformis*) is an ecologically, culturally, and economically important species in the Laurentian Great Lakes. Lake Whitefish have been a staple food source for thousands of years and, since 1980, have supported the most economically valuable and productive commercial fishery in the upper Great Lakes. Climate change, specifically change in temperature, wind, and ice cover, is expected to impact the ecology, production dynamics, and value of this fishery, because the success of recruitment to the fishery has been linked with these climatic factors. We used linear regression to examine the relationship between fall and spring temperature indices, fall wind speed, winter ice cover, and Lake Whitefish recruitment in 13 management units located in the 1836 Treaty Waters, a culturally and commercially important region for the fishery. Corrected Akaike's Information Criterion comparisons indicated that the inclusion of selected climate variables significantly improved model fit in eight of the 13 management units evaluated. Isolating the climate-recruitment relationships and projecting recruitment using the Coupled Hydrosphere-Atmosphere Research Model suggested increased Lake Whitefish recruitment in the majority of the 1836 Treaty Waters management units given projected changes in climate. *Keywords: Fish management, Climate change, Lake Whitefish, Recruitment.*

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MACCOUX, M.J., Milwaukee Metropolitan Sewerage District, 260 West Seeboth Street, Milwaukee, WI, 53204. **Validation of a total phosphorus mass-balance model for Green Bay, Lake Michigan.**

A previously developed total phosphorus mass-balance model for Green Bay was calibrated using recent loading estimates from 1994-2008. While the chloride simulations agreed with the data, the total phosphorus model had a large deficit for 1999-2004. In an effort to post-audit and further validate the model, mass loading estimates from an earlier time period were used to simulate total phosphorus concentrations. Due to the absence of current loading estimates since 2008, the period of 1980-1993 was chosen. Loading estimates used were those reported to the International Joint Commission and concentration data for lower Green Bay were made available by the Green Bay Metropolitan Sewerage District, beginning in 1986. Additional sources of data were used where available. The previously reported fit statistics, i.e., average relative percent error and root mean error, were also calculated for comparison. Error estimates compared favorably and no major discrepancies were observed. The original calibration of the model performed well and furthers speculation that the 1999-2004 increase in total phosphorus may be an anomaly explained by internal loading.
*Keywords: Green Bay, Mass balance, Water quality.*

MAHMOOD, M.[1], BLUKACZ-RICHARDS, A.[2], BAUMANN, P.C.[3], MCMASTER, M.[2], and ARHONDITSIS, G.B.[1], [1]University of Toronto, Ecological Modelling Laboratory, Toronto, ON, M1C 1A4; [2]Environment Canada, Burlington, ON; [3]U.S. Geological Survey, Columbus, OH. **A Bayesian methodological framework for setting fish tumour occurrence delisting criteria: A case study in St. Marys River Area Of Concern.**

Fish tumours and other deformities is one of the Beneficial Use Impairments established to identify Areas of Concern in the Great Lakes basin. According to the International Joint Commission guidelines, the characterization of non-impairment in a particular site requires the incidence rates of fish tumours to not exceed rates at control sites. We present a Bayesian modelling framework that is founded upon the explicit consideration of the sampling bias in tumour observations as well as the causal association between important covariates and tumour occurrence. Our case study is the St. Marys River, an international waterway that flows from Lake Superior into the North Channel of Lake Huron. Data from 2009 indicate that fish tumour incidence rates were elevated at the Bellevue Marina and Partridge

Point sites relative to the Batchawana Bay site, which represented the reference conditions in our analysis. Fish age was the single most important covariate of the tumour incidence rates, followed by the fork length, and the liver or gonad weights. We also introduce a new criterion that stipulates the likelihood of tumour incidence to be lower than 10% for a certain fraction (or greater) of the fish samples collected, which may be a more sensible way to characterize the prevailing conditions in potentially impacted locations. *Keywords: Decision making, Stastical modeling, Fisheries, Bayesian analysis, St. Marys River, Fish tumours.*

MAITLAND, B.M.[2], O'MALLEY, B.P.[3], O'BRIEN, T.O.[1], ARMENIO, P.M.[1], WATSON, N.M.[1], ROSEMAN, E.F.[1], and TAYLOR, W.W.[4], [1]USGS Great Lakes Science Center, Ann Arbor, MI, 48105; [2]University of Alberta, Department of Renewable Resources, 751 General Service Bldg., Edmonton, AB, T6G 2H1; [3]Cornell Biological Field Station, 900 Shackleton Point Road, Bridgeport, NY, 13030; [4]Department of Fisheries and Wildlife, Michigan State University, East Lasing, MI, 48824. **Zooplankton community dynamics in a northern Lake Huron embayment: The influence of water temperature and larval fish abundance.**

Seasonal dynamics of nearshore zooplankton communities in Lake Huron have received less attention than in the offshore, where recent changes have occurred in species composition and productivity. We sampled the zooplankton community of St. Martin Bay Lake Huron during 2008-09 to determine seasonal patterns in abundance and biomass. We compare nearshore zooplankton dynamics to those reported from the offshore, as well as to larval fish and water temperatures from the bay. Copepods contributed most to biomass, followed by herbivorous cladocerans, microzooplankton, and predatory cladocerans. The predatory cladoceran *Cercopagis* was abundant in the bay during 2008, but not present in 2009. *Bythotrephes* was observed in both years of our study, but was more dominant in 2009. Microzooplankton were a relatively insignificant portion of biomass and were mainly composed of copepod nauplii, *Dreissena* veligers, and rotifers, in order of decreasing abundance. Water temperature and larval fish abundance are used to explain differences in zooplankton patterns between and among years. Finally, we show that calanoid copepods appear to dominate the zooplankton community of the near- and offshore waters of Lake Huron, while herbivorous cladocerans and cyclopoid copepods appear to remain at low abundances. *Keywords: Invasive species, Zooplankton, Lake Huron.*

MAJARREIS, J.M.[1], HIRIART-BAER, V.P.[2], BOEGMAN, L.[3], HOWELL, E.T.[4], and SMITH, R.E.H.[1], [1]Department of Biology, University of Waterloo, 200 University Ave. W., Waterloo, ON, N2L 3G1; [2]Canada Centre for Inland Waters, 867 Lakeshore Rd., Burlinton, ON, L7S 1A1; [3]Queen's University, 207 Stuart St, Kingston, ON, K7L 2W1; [4]Ontario Ministry of the Environment, 125 Resources Rd, Toronto, ON, M9P 3V6. **Near-bed physical conditions in the nearshore of East Basin Lake Erie and the potential for mussel-mediated benthic phosphorus enrichment.**

The East Basin of Lake Erie has surface phosphorus (P) and phytoplankton chlorophyll a (chl a) concentrations consistent with oligotrophic lakes. Despite this, *Cladophora* has been reaching nuisance levels in the nearshore benthos. Mussel excretion has been hypothesized as a source of phosphorus (P) promoting this growth but its role will be heavily influenced by near-bed hydrodynamics in the shallow nearshore zone. To describe such hydrodynamics, an Acoustic Doppler Current Profiler (ADCP) was concurrently deployed with eight RBR thermistors (temperature sensors) and four chl a sensors mounted at 10cm intervals from the bed. They were deployed at stations in the vicinity of the Grand River (Ontario) on select dates in May-October 2013. Near-bed velocity, temperature, and chl a profiles were compared among stations of differing proximity to the river mouth and of differing depths. Turbulence and eddy diffusivity were calculated using a variety of equations and ADCP-derived velocity. Near-bed profiles of temperature, velocity and chl a were temporally and spatially variable and there was a wide range of estimated turbulence and eddy diffusivity. The implications for potential *Cladophora* fertilization will be discussed. *Keywords: Dreissena, Cladophora, Lake Erie.*

MANDELIA, A.J., URBAN, N.R., and PERLINGER, J.A., Michigan Technological University, 1400 Townsend Drive, Houghton, MI, 49931. **Modeling PCB Transport in the Torch Lake Area of Concern.**

The presence of polychlorinated biphenyls (PCBs) in Torch Lake (Houghton County, MI) Area of Concern has led to fish consumption advisories. It is unclear what the source is of the elevated PCB concentration in the lake water, so we developed a mass balance model to quantify the source(s). This model is applied to individual congeners to predict the magnitude of additional source (beyond the known inputs) required to explain the measured concentration in the lake water. The congener pattern of the predicted additional source suggests that the source is not atmospheric deposition, but a local source with a higher degree of chlorination than atmospheric deposition. First-order error propagation and a Bayesian approach have been used to assess the uncertainty and the major contributors to the un-

certainty in the model prediction. Uncertainty in physical-chemical properties of PCB congeners contributes as much uncertainty to the model prediction as does variability in measured PCB concentrations. *Keywords: PCBs, Mass balance, Model testing.*

MANOME, A.F.[1], WANG, H.[2], and BAI, X.[1], [1]CILER, University of Michigan, 4840 S State Rd, Ann Arbor, MI, 48108; [2]NOAA - GLERL, 4840 S State Rd, Ann Arbor, MI, 48108.
**Ice-hydrodynamic coupled simulation in Lake Erie with FVCOM.**

The Unstructured Grid Finite Volume Coastal Ocean Model (FVCOM) along with its ice sub-model is configured for Lake Erie with the operational-level grids used at GLERL. The model is forced by hourly surface winds, air temperature, specific humidity, and total cloud cover from the surface meteorological measurements the National Data Buoy Center and the Coastal Marine Automated Network. The simulation results will be validated in comparison with ice analysis charts from the Great Lakes Ice Atlas at GLERL, the water surface temperature from the Great Lakes Surface Environmental Analysis, and the moored instruments data during the International Field Years on Lake Erie. We will test different time integration schemes to search a neutrally-stable time integration scheme with low viscosity and diffusivity. These new schemes are used to simulate current structure, thermocline structure, and ice conditions. *Keywords: Ice, Lake Erie, Model testing.*

MAO, M. and XIA, M., University of Maryland Eastern Shore, Department of Natural Sciences, Princess Anne, MD, 21853. **Application of unstructured grid wave models to Lake Michigan.**

It is widely known that waves plays a critical role in coastal circulation, so it is very important to simulate wave dynamics in lake and shallow regions. An unstructured triangular mesh wave model - SWAN (Simulating WAves Nearshore) was configured to Lake Michigan to understand the surface gravity wave pattern, and it could provide remote wave information for coastal (e.g. Grand Haven) wave simulation. In order to understand the temporal variation and spatial distribution of wave parameters near islands, inlet, and nearshore regions, we ran a series of wave simulations using hourly wind. Some conclusions have been given, such as: wind from deep lake part had major impact on the wave dynamics of Lake Michigan; wave simulation is very sensitive to the parameterizations of whitecapping; bathymetry-induced refraction was observed near islands and costal lines. To better understand the effect of bathymetry on wave dynamics, some ideal wind speed cases have been conducted and given discussion. Finally, a brief comparison between unstructured SWAN and unstructured-grid finite-volume surface wave model (FVCOM- SWAVE) had been given comparison. The accurate simulation of wave dynamics could be useful to improve the understanding of the effect of wave and wave-current interactions in nearshore circulation in the future *Keywords: Hydrodynamics, Waves, Lake Michigan.*

MARCACCIO, J.V. and CHOW-FRASER, P., McMaster University, 1280 Main Street West, Hamilton, ON, L8S 4K1. **Creation of a Basin-wide Inventory of Invasive *Phragmites* for the Canadian Great Lakes Coastlines Using PALSAR and LANDSAT Imagery.**

Invasive *Phragmites* or Common Reed, is an invasive perennial grass that is rapidly spreading throughout the Great Lakes and further inland. It readily outcompetes native species in shallow wetland environments, replacing diverse native vegetation with vast monocultures that are not as useful or beneficial to fauna. In partnership with the Michigan Technological Research Institute (MTRI), this project aims to map invasive *Phragmites* throughout the basin within 10 km of the Canadian shoreline of the Great Lakes. Over the summer of 2013, 69 sites were field-truthed to obtain wetland type and density information for the Canadian portions of Lakes Erie, Ontario, Huron & Georgian Bay. Corresponding shoreline for Lake Superior was sampled separately by MTRI. Available satellite and orthophotos are used to further delineate obvious land cover types, such as urban, forest, and agriculture. These data, combined with LANDSAT and PALSAR data, are then used to classify land cover types in the area of interest. Classifications have been cross-validated with random samples from the delineated areas and showed an overall accuracy of 90%. We provide this inventory to managers and researchers in order to combat the spread of *Phragmites* in high-risk areas. *Keywords: GIS, Phragmites australis, Great Lakes basin.*

MARINI, L.[1], TENCZAR, N.[1], COLLINGSWORTH, P.[2], TEPAS, K.[2], GATZKE, L.[1], XU, W.[3], ROLOFF, J.[1], MINSKER, B.S.[3], KOOPER, R.[1], ANGELO, B.[1], and MILLER, B.[3], [1]National Center for Supercomputing Applications, Urbana, IL, 61801; [2]U.S. Environmental Protection Agency, Chicago, IL, 60604; [3]University of Illinois at Urbana-Champaign, Urbana, IL, 61801. **Distributed Data Management for the Great Lakes.**

We have developed an open-source Web-based Geodashboard and archival service to aggregate, store, and visualize heterogeneous data from a variety of sources to facilitate discovery and retrieval by researchers and stakeholders in the Great Lakes region. The system allows data owners to maintain their own primary archives, and have the Geodashboard index their data, or upload the data directly to the archival service. The system currently provides access to water quality data from EPA, USGS, and NOAA, but new data sources can easily be added. The system does not make any assumptions about the nature of the data besides requiring each data point to be defined in time and space. The user can explore the data using interactive visualizations (line graphs, box and whisker plots, depth graphs) and dynamic map layers. To enable advanced query capabilities, users can specify an area of interest by drawing polygons on a map or specifying lake or basin boundaries, providing a time interval, or parameters of interest. Data fitting the specific query can be downloaded for further processing outside the system or visualized inside the system. We will provide an overview of the system, demonstrate how to search, visualize, download and contribute data. *Keywords: Data storage and retrieval, GIS.*

MARKLE, C.E. and CHOW-FRASER, P., McMaster University, 1280 Main Street West, Hamilton, ON, L8S 4K1. **Comparing Approaches to Model Habitat Suitability for Blanding's Turtles (Emydoidea blandingii) in the Georgian Bay Archipelago.**

Blanding's turtles are designated a threatened species and require a variety of habitat types to carry out their life processes. Previous research confirms that this species has regional differences with respect to habitat use that makes it difficult to develop a model of habitat use across their entire geographic range. We develop a habitat suitability model based on habitat use by Blanding's turtles in an island of eastern Georgian Bay. Our study compares 4 regional-scale habitat suitability models for the Blanding's turtle created with 2 approaches at 2 different scales. We first used eCognition Developer 64 to classify habitat types in 1-m resolution IKONOS images for all islands located throughout the Georgian Bay archipelago. We then used R 2.15.1 to develop four generalized linear models that predict the presence/absence of Blanding's turtles based on the suitability of available habitat types. To determine the most effective model for mapping suitable habitat, we compare model predictions with data from a 2013 ground survey of 10 islands. Our results will greatly enhance the ability of environmental agencies to identify critical habitat for the Blanding's turtle throughout the thousands of islands in eastern Georgian Bay, and we recommend that this approach be used to conserve other freshwater turtle species. *Keywords: Georgian Bay, Turtles, GIS, Reptiles.*

MARTIN, I.A.M., ENGLISH, M.C., and MACRAE, M.L., Department of Geography and Environmental Studies, Wilfrid Laurier University, 75 University Ave W, Waterloo, ON.

**Examination of field scale hydrological processes under three different tillage methods; Conservation Till (CT); Annual Till (AT); and No Till (NT).**

In the wake of the severe algal blooms of 2011 and 2013 in the Great Lakes, international governing bodies such as the United Nations, are advocating for increased studies on nutrient dynamics within agricultural systems. Understanding farm contributions to nutrient loads entering the Great Lakes involves quantifying nutrient export from different tillage practices common in the Great Lakes basin, which include; no-till (NT), conservation no-till (CT) and annual tillage (AT). Understanding differences in nutrient export from different tillage practices may well be related to structural differences in the upper portion of the vadose zone which impact infiltration, soil moisture and overall effectiveness of artificially draining cultivated fields by tiles and exporting nutrients to surface water bodies. Added to the importance of understanding how different tillage practices impact hydrology and the efficiency of exporting of nutrients to surface water bodies is how present increased year-to-year climatic variability and future climate/hydrological change will impact these systems. This study examines the hydrological balances within three ~.6 ha tiled plots each with different (NT, CT, AT) tillage practices but common soil type, nutrient application, cultivated crop, and precipitation patterns. *Keywords: Agriculture, Hydrologic budget, Lake Erie.*

MARTIN, P.A.[1], HUGHES, K.D.[2], DE SOLLA, S.R.[1], and WESELOH, D.V.C.[3], [1]Environment Canada, 867 Lakeshore Road, Burlington, ON, L9R 4A6; [2]1944 Parkside Drive, Pickering, ON, L1V 3N5; [3]Environment Canada, 4905 Dufferin Street, Downsview, ON, M3H 7T4. **Long-term Trends in Contaminants in Aquatic Wildlife in the Hamilton Harbour Area of Concern.**

Long-term trends in contaminant exposure were examined in eggs of two aquatic-feeding species, the herring gull (*Larus argentatus*) and the snapping turtle (*Chelydra serpentina*), collected from within the Hamilton Harbour Area of Concern (AOC). Significant declines in concentrations of sum PCBs and other organochlorines were evident in gull eggs from a nesting colony within the harbour and turtle eggs from two AOC wetland/creek locations from the 1980s-2012. Overall concentrations of contaminants declined between 78 and 94% in gull eggs and between 36 and 93% in turtle eggs. In addition, percentages of non-metabolizable congeners increased and percentages of congeners metabolized by P450 1A enzymes decreased in eggs of both species upon grouping PCB congeners according to structure-activity relationships. Significant temporal increases in a wildlife contaminant index, developed to summarize trends in organochlorine exposure, were found in both species reflecting an overall increase in protection to predatory wildlife that feed on the gull and turtle eggs in the AOC. Large decreases in contaminants burdens in these two species which forage at two different geographic scales within the AOC are reflective of improved environmental conditions in the harbour and support their utility as good wildlife indicator species. *Keywords: PCBs, Aquatic-feeding wildlife, Hamilton Harbour, Indicators.*

MARTY, J.[1] and POTTER, S.[2], [1]WSP Canada, 2611 Queensview Drive, Ottawa, ON, K2B 8K2; [2]SL Ross, 200 - 1140 Morrison Dr., Ottawa, ON, K2H 8S9. **Assessing the risk of oil and HNS spills in Canadian waters: methods and results for the Great Lakes- St Lawrence River ecosystems.**

This study is the first risk assessment aiming to characterize the risk of marine spills of oil and hazardous noxious substances (HNS) in Canadian waters. Risk was defined as the product of the probability of a spill occurring and the potential impacts should a spill occur. These two elements were estimated for 4 regions of Canada, including the Great Lakes- St Lawrence River system. Oil spill frequency was estimated based on mean annual Canadian traffic and oil cargo volumes as crude oil and refined products. Oil spill frequencies were described according to four spill volume categories ranging from 10 m3 to ≥ 10,000 m3. HNS frequencies were expressed as mean annual volumes of 4 classes of chemicals. Impacts were estimated using an Environmental Sensitivity Index (ESI) based on geographic layers describing the physical, biological and human environments. Within the Great Lakes- St Lawrence River system, the highest risk values for small to medium size spills were observed in the St Lawrence River and in Lake Ontario. Within each lake, nearshore areas had a higher risk compared to off shore areas. A comparison between Great Lakes data and the rest of Canada indicated a lower risk in the Great Lakes due to low volumes but also due to the lack of data to describe biological features compared to marine regions. *Keywords: Spatial analysis, Oil and HNS spills, Risk assessment.*

MASON, L.A.[1], WANG, J.[2], RUTHERFORD, E.S.[2], CLITES, A.H.[2], ASSEL, R.A.[2], RISENG, C.M.[1], SMITH, S.D.P.[1], MCINTYRE, P.B.[3], BRECK, J.T.[1], and ALLAN, J.D.[1], [1]University of Michigan, Ann Arbor, MI, 48109; [2]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, 48108; [3]University of Wisconsin, Madison, WI, 53706. **Fine-scale Analysis of Changes in Surface Water Temperature and Ice Cover in the North American Great Lakes.**

Climate change has caused decreases in ice cover and increased surface water temperatures that may affect Great Lakes food webs and fisheries. For example, less winter ice

permits greater disturbance of fish eggs spawned in nearshore areas, while warmer surface temperatures may increase fish metabolism and growth, but reduce upwellings that stimulate production of lower trophic levels. Previous studies have reported temporal trends in winter ice cover and summer warming at the Great Lake or basin scale, but not at the regional or pixel scale needed for forecasting food web impacts. We analyzed remotely sensed data at fine spatio-temporal scales on ice cover available from 1973-2011, and summer surface water temperatures from 1994-2012, integrated in the Great Lakes Aquatic Habitat Framework geospatial database. We found the temporal and spatial extent of ice cover varies greatly within and across the Great Lakes, variability being greatest in eastern Lake Superior and lowest in Lake Erie. We found surface water warming trends to be greatest within each lake in deep areas due to the ice albedo feedback, and near lakes' eastern shorelines influenced by dominant southwest winds. Our results should improve spatio-temporal resolution of forecasts of climate change impacts on Great Lakes food webs. *Keywords: Climate change, Ice, GIS.*

MASON, S.A.[1], ERIKSEN, M.[2], and EDWARDS, W.J.[3], [1]SUNY Fredonia, Houghton Hall 220, Fredonia, NY, 14063; [2]5 Gyres Institute, 2122 S. Spaulding Ave., Los Angeles, CA, 90016; [3]Niagara University, 5795 Lewiston Road, Lewiston, NY, 14109. **Great Lakes Plastic Pollution Survey.**

Since the 'discovery' of an accumulation of plastics in the North Pacific Subtropical Gyre in 1999 and recent events such as the 2011 Japanese Tsunami, marine debris has received increased attention and public awareness. To date, however, research and even public media campaigns have focused upon oceanic systems. Globally, the salt-water environs of our oceans do dominate the earth's surface, but that water cycles through freshwater systems as it makes its way from sky to sea, accumulating our trash along the way. United Nations' reports suggest that 80% of the oceanic debris comes from land, and it is perpetually postulated that litter makes its way to the oceans by way of freshwater systems. Despite the expectation that oceanic debris was likely transported through a freshwater system, very little research with regard to marine debris has focused upon these freshwater systems. Given the size and importance of the Great Lakes, they provide a significant representative model for other freshwater ecosystems throughout the world. During the summers of 2012 and 2013, we conducted the first-ever survey for plastic pollution within the open-waters of the Great Lakes. Results on the concentrations and distributions of plastic pollution for all 5 of the Great Lakes will be presented and discussed. *Keywords: Pollutants, Plastic, Assessments, Open-water.*

MASSON, C., Freshwater Consulting, Toronto, ON. **Towards a Great Lakes - St. Lawrence River Regional Vision Decision.**

As Great Lakes and St. Lawrence River commons governance evolves, the challenges of building a shared vision for regional renewal and long-term transformation remain unsolved. This study synergizes vision statements and organizing principles deployed by entities maintaining strategic focus with respect to transboundary freshwaters, ecosystems, sustainability, and/or environmental/social justice that are located: 1) across the GLSLR basin, 2) within Canada and United States, or 3) at other global, regional and local levels. Using triangulated grounded theory, systems approaches, logic models and narrative-based inductive methods, over 2000 declarative statements, works with creative, historical or legacy import and supporting literature were reviewed and compended. Project architecture includes development of a taxonomy for systemic/cyclic data collection, interpretation, synthesis, reporting and interoperability. This poster depicts a non-linear strategic visioning pathway integrating five key aspects: legitimacy, complexity, collaboration, reciprocity and consilience. The aim is to provide a reliable standard of subject matter insight, foresight and hindsight to guide regional strategic decision making for GLSLR leaders, governments, authorities, aboriginal communities, institutions, managers, ENGOs, stakeholders and citizens. *Keywords: Decision making, Vision statements and organizing principles, Policy making, Regional vision, Boundaries, Strategic pathway.*

MAY, C.J.[1], MARSCHALL, E.A.[1], KULASA, M.R.[1], ROSEMAN, E.F.[2], TAYLOR, W.W.[3], and LUDSIN, S.A.[1], [1]The Aquatic Ecology Lab, The Ohio State University, 1314 Kinnear Rd, Area 200, Columbus, OH, 43212; [2]USGS, 1451 Green Rd, Ann Arbor, MI, 48105; [3]Center for Systems Integration and Sustainability, Dept. of Fisheries & Wildlife, Michigan State U., 1405 S. Harrison Road, Suite 115 Manly Miles Bldg., East Lansing, MI, 48823. **Larval Walleye Recruitment and Zooplankton Availability: Testing the Match-Mismatch Hypothesis in Lake Erie.**

Match-mismatch dynamics between larval fish and their zooplankton prey have been shown to be important in understanding recruitment variation in marine fishes. Few studies, however, have explored these dynamics in the Laurentian Great Lakes. Herein, we explored what role zooplankton availability during the larval stage might have played in driving recruitment variation in Lake Erie Walleye (*Sander vitreus*). Walleye are a model species to test a marine derived hypothesis because 1) their life-history characteristics are typical of many pelagic marine fishes and 2) the abundance of young-of-year fishes is a strong predictor of age-2 abundance in western Lake Erie ($R^2$=0.89). Towards this end, we compared crustacean zooplankton and larval Walleye abundance data from 1994-1999 and 2011-2013. Analysis of Walleye abundance estimates revealed no obvious differences between study periods. However, both average zooplankton size and density decreased through time. Ultimately, our findings suggest that early spring (April through early May) match-mismatch dynamics are in part driving Walleye recruitment dynamics, with the recent series of weak year-classes likely being due to a zooplankton assemblage that is both low in abundance and small-sized. *Keywords: Recruitment, Lake Erie, Zooplankton.*

MAYER, J.E.[1], SEEKAMP, E.L.[1], CHARLEBOIS, P.M.[2], and HITZROTH, G.A.[2], [1]North Carolina State University, Parks, Recreation and Tourism Management, Campus Box 8004, Raleigh, NC, 27695-8004; [2]Illinois-Indiana Sea Grant, Chicago Botanic Garden, 1000 Lake Cook Road, Glencoe, IL, 60022. **Predicting Behavioral Intention of Organisms-in-Trade Hobbyists: A Study to Enhance Outreach in the Great Lakes Region.**

The spread of aquatic invasive species (AIS) in the Great Lakes has led to a loss of native species and costly mitigation efforts. Hobbyists in the organisms-in-trade (OIT) industry (e.g. aquarium, outdoor pond, and water garden owners) have been identified as vectors of AIS release. This study collected baseline data to inform Illinois-Indidana Sea Grant's efforts to create a new OIT hobbyist campaign. Specifically, the study (1)identifies theoretical constructs from the Theory of Planned Behavior (TPB) and Value-Beleif-Norm Theory (VBN) that help explain intention to perform OIT purchase and disposal behaviors to prevent the spread of AIS and (2)compares the effects of the constructs on purchase and disposal behaviors using seemingly unrelated regression (SUR). A survey was distributed to OIT hobbyists living in the eight Great Lake states (n=542) in 2013. Regression analyses reveal that VBN constructs have direct, positive effects on likelihood of performing future desired purchase and disposal behaviors. One TPB construct also significantly predicted likelihood of performing future disposal behaviors. SUR results suggest that the effect of these constructs differs among purchase and disposal behaviors. Theoretical and managerial implications will be discussed, along with suggestions for future campaign outreach strategies. *Keywords: Behavior change, Campaign outreach, Invasive species.*

MCCALLUM, E.S., CHARNEY, R.E., and BALSHINE, S., Psychology Department (Rm 102), Building 34, McMaster University, 1280 Main Street West, Hamilton, ON. **Persistence of the round goby in a contaminated ecosystem.**

Post-establishment dynamics of invasive species have been under-studied, but are important for management practices of invasive species known to impact native communities. As a highly invasive species, round goby (*Neogobius melanostomus*) present a threat to the areas they invade by out-competing native species for resources. Furthermore, as a pollution tolerant species, round goby present a second threat by acting as a possible vector for contaminant transfer up the food web in invaded ecosystems with areas of contamination. We have sampled round goby for 11 years (2002 - 2012) at six locations (four low contamination sites and two high contamination sites) in Hamilton Harbour, ON, Canada to investigate their population dynamics both across time and areas of differing contaminant load. Across sampling years, round goby abundance has declined at low contamination sites, but remained stable at high contamination sites. In this study we also address how body size and reproductive characteristics of round goby have varied both across time and between areas of low and high contamination. We highlight the importance of assessing invasive species population dynamics as they persist and integrate into a native ecosystem to better inform their management. *Keywords: Round goby, Pollutants, Hamilton Harbour, Population dynamics, Invasive species.*

MCCARTHY, F.M.G.[1], MCANDREWS, J.H.[2], and PAPANGELAKIS, E.[3], [1]Dept. of Earth Sciences, Brock University, St. Catharines, ON, L2S 3A1; [2]Dept. of Ecology and Evolutionary Biology, University of Toronto, Toronto, ON, M5S 3B2; [3]Dept. of Geography, University of British Columbia, Vancouver, BC, V6T 1Z4. **Drought in the Lake Huron basin-Causes and Implications.**

Paloeclimate reconstructions using pollen-derived transfer functions allowed us to produce a water budget that demonstrates that Lake Huron levels fell quickly in response to drought conditions during the early Holocene. The lake became hydrologically closed within centuries following the diversion of Laurentide Ice Sheet meltwater from the Great Lakes basin and the subsequent closur eof Lake Superior. Lake Hough was isolated from Lake Stanley- which itself was transected by the exposed Alpena-Amberley ridge by ~8400 years ago. The negative water budget, combined with the seepage of briny groundwater into the lake basin, would have produced relatively high salinities in the Manitoulin and Goderich basins, and even in Lake Hough, an increase in dissolved ions is recorded by the preservation of ostracods and by a thecamoebian fauna tolerant of brackish conditions. Water levels rose quickly around 8000 years ago in response to the wetter climates that allowed the establishment of the Great Lakes-St. Lawrence Forest, but there is evidence of another less severe drought-driven lowstand during the mid-Holocene hemlock "crash". The sensitivity of the Great Lakes to climate change is evident from the rapid changes in lake level and water quality in the relatively recent geologic past. *Keywords: Lake Huron, Atmosphere-lake interaction, Drought.*

MCCARTHY, M.J.[1], NEWELL, S.E.[2], and GARDNER, W.S.[1], [1]UTexas Marine Science Institute, 750 Channel View Drive, Port Aransas, TX, 78373; [2]Boston University, 675 Commonwealth Ave, CIS130, Boston, MA, 02155. **Ammonium regeneration in the water column supplies over half of the ammonium demand in Taihu Lake (China).**

Water column ammonium dynamics were evaluated in Taihu Lake (China) during a summer *Microcystis* bloom (August 2013). Taihu Lake is very large, shallow, and eutrophic, with annual cyanobacteria blooms. We used stable isotope ($^{15}$N-ammonium) enrichments to quantify ammonium regeneration and potential uptake rates. Ambient ammonium concentrations in the lake were measured in samples filtered immediately in the field using 0.2 µm nylon syringe filters and ranged from 0.26 µM in surface waters in the center of the lake to 1.79 µM in bottom waters at the site furthest from the main lake body. Potential ammonium uptake rates were higher in the light than dark, but dark rates were 70% of light rates, suggesting that heterotrophic ammonium demand exceeded autotrophic ammonium assimilation. Ammonium regeneration ranged from 0.018 to 0.446 µmol N $L^{-1}$ $h^{-1}$ and could supply 54% of water column ammonium demand. For the entire lake, water column ammonium regeneration supplies 93,000 metric tons N per year, which exceeds annual total nitrogen load by a factor of nearly four. These results show that internal nitrogen processing plays a more important role in driving primary production than external inputs and must be considered in nutrient budgets and ecosystem models. *Keywords: Cyanophyta, Ammonium, Nutrients, Regeneration, Eutrophication, Uptake.*

MCGOLDRICK, D.J.[1], CHAN, C.[2], DROUILLARD, K.G.[3], BARRESI, E.[1], KEIR, M.J.[1], and CLARK, M.G.[1], [1]Environment Canada, Water Science and Technology Directorate, Burlington, ON, L7R4A6; [2]CASSEN Testing Labs, Toronto, ON, M9W6H3; [3]Great Lakes Institute for Environmental Research, University of Windsor, Windsor, ON. **Levels, trophic magnification, and temporal trends of organosiloxanes in aquatic biota from Canadian lakes.**

Siloxanes are high production volume chemicals that are common components of many personal care products, cosmetics, as well as many industrial products. In Canada, screening assessments have added on siloxane, octamethylcylcotetrasiloxane (D4), to the list of toxic substances under the Canadian Environmental Protection Act, 1999 (CEPA). As a result, the levels of organosiloxanes, including D4, are being monitoring in fish from Canadian lakes as part of Environment Canada's National Fish Contaminants Monitoring and Surveillance Program to better understand the occurrence, concentrations, trophic magnification, and trends of these compounds in the Canadian Environment. Levels of siloxanes were higher and detected more frequently in Lake Trout from the Great Lakes, specifically in Lake Ontario at the monitoring station closest to the inflow of the Niagara River. Trophic magnification factors (TMF) for siloxanes were determined using aquatic biota from the Western Basin of Lake Erie, and were found to be highly sensitive to food web structure. TMF values >1, indicating biomagnification, were observed for 2 cyclic siloxanes in only 1 of 5 food web configurations. Retrospective analyses of frozen specimens are underway and will determine the levels and trends of siloxanes in Lake Ontario Lake Trout from 2003 to 2012. *Keywords: Environmental contaminants, Biomonitoring, Fish.*

MCGREW, A.R. and MCNAUGHT, A.S., Central Michigan University, 1200 S. Franklin St., Mount Pleasant, MI, 48859. **Omnivory and prey-switching of the invasive mysid, *Hemimysis anomala.***

*Hemimysis anomala* is a recent invader of the Great Lakes. This mysid is a known omnivore with the potential to directly and indirectly affect multiple trophic levels. The capacity for these organisms to consume phytoplankton, and whether this capacity changes with food resource availability or life stage, may drive the scale of their impact on food webs. *Hemimysis* were collected in the summer and fall of 2013 in Muskegon, MI using vertical net tows. In phytoplankton feeding experiments, five juvenile and five adult mysids were isolated and starved in two separate 600 mL containers. Varying densities of two algal taxa were provided as a food resource. The number of algal cells consumed per animal, per hour was calculated. A second experiment will investigate prey-switching between phytoplankton and zooplankton prey to evaluate if and when density-dependent prey-selection occurs. Experiments suggest that *Hemimysis* consumption of phytoplankton is dependent on the density of available food, but not on their life stage. A noticeable shift between consumption of phytoplankton and zooplankton prey is expected in the prey-switching experiment. *Keywords: Phytoplankton, Invasive species, Zooplankton.*

MCKAY, R.M.L.[1], ROZMARYNOWYCZ, M.J.[1], BEALL, B.F.N.[1], BULLERJAHN, G.S.[1], OYSERMAN, B.[2], SMITH, D.[3], and TWISS, M.R.[3], [1]Department of Biological Sciences, Bowling Green State University, Bowling Green, OH, 43403; [2]Department of Bacteriology, University of Wisconsin-Madison, Madison, WI, 53706; [3]Department of Biology, Clarkson University, Potsdam, NY, 13699. **Ice cover as a factor driving microbial community composition in the Lake Erie.**

Lakes serve as rapid responding sentinels of human influence on the natural environment rendering them powerful tools to advance our understanding of a changing climate on microbial community structure and function. Through collaboration with U.S.- and Canadian Coast Guards, winter surveys have been conducted on Lake Erie since 2007. The surveys have captured extremes in ice extent ranging from expansive ice cover through 2011 to nearly ice-free waters in winter 2012, a condition driven by a warm positive Arctic Oscillation. We showed that dramatic changes in annual ice cover were accompanied by equally dramatic shifts in phytoplankton- and bacterial community structure. Expansive ice cover documented for Lake Erie in winters 2010 and 2011 supported ice-associated phytoplankton blooms dominated by physiologically robust, filamentous centric diatoms. By comparison, ice free conditions promoted the growth of small-sized cells supported by analysis of size-fractionated chl a and flow cytometry. Additional insights into microbial community dynamics were gleaned from short 16S rRNA tag (Itags) Illumina sequencing. UniFrac analysis of iTag sequences showed clear separation of microbial communities related to presence or absence of ice cover. These changes are expected to have consequences for Lake Erie's food web. *Keywords: Ice, Microbiological studies, Diatoms.*

<u>MCLEOD, A.M.</u>, DROUILLARD, K.G., and HAFFNER, G.D., Great Lakes Institute for Environmental Research, University of Windsor, Windsor, ON, N9B 3P4. **The Off-shore Shunt: The Influence of Lake Trout on Nutrient Recycling.**

Understanding nutrient and energy flow is crucial to understand ecosystem productivity. Organisms require nutrients, such as Nitrogen (N) and Phosphorus (P) in specific ratios to maintain populations, health, and growth. Quantifying nutrient recycling has long been a challenge in aquatic ecology. Here we propose that by using ubiquitous, well-studied, stable contaminant markers, such as polychlorinated biphenyls (PCBs), we can track the number of meals an organism has eaten, and hence monitor the flow of both energy and nutrients through food webs. We measured PCB concentrations in multiple age classes of Lake Trout from three basins of Lake Huron over three summers (2010, 2011, and 2012). Using PCBs we are able to quantify the amount of N and P recycled back to the system by different age classes of fish and compare and contrast these estimates among the three basins of Lake Huron (Georgian Bay (GB), Main Basin (MB), and North Channel (NC)). For example, on average, a 4 year old Lake Trout from the NC, MB, and GB will recycle 157, 1812, and

4862 g of N, respectively, and 5, 108, and 299 g of P, respectively, over its lifespan. The differing rates of nutrient recycling observed in the three basins are a function of prey availability, such that the basin with the lowest prey (GB) has the highest nutrient recycling rates. *Keywords: Nutrients, Bioaccumulation, Fish populations.*

MEAD, J.L.[1], SCHIFF, S.L.[1], VENKITESWARAN, J.J.[1], ROSAMOND, M.S.[1], ELGOOD, R.J.[1], TAYLOR, W.D.[1], SPOELSTRA, J.[1,2], CEJUDO, E.[1], CUMMINGS, F.[1], CHEN, G.[1], HOOD, J.L.A.[1], BROWN, S.J.[2], and ANDERSON, M.[3], [1]University of Waterloo, 200 University Ave West, Waterloo, ON, N2L 3G1; [2]Environment Canada, 867 Lakeshore Rd, Burlington, ON, L7R 4A6; [3]Grand River Conservation Authority, 400 Clyde Rd, PO Box 729, Cambridge, ON, N1R 5W6. **Geochemistry of the Grand River: Before and After Wastewater Treatment Plant Modifications.**

The Grand River Watershed is home to over 950,000 people. The river receives treated wastewater from 29 wastewater treatment plants (WWTPs) and provides drinking water to many municipalities along its length. Watershed population is projected to grow to 1.4 million people in the next 20 years. The geochemistry and health of the Grand River is vital since approximately 50% of people living in the watershed rely on the river for drinking water. Twenty-three sites on the length of the Grand River were sampled seasonally to gain a greater understanding of river geochemistry, impacts of agricultural zones, urban zones and WWTPs on the river. With increasing concern about WWTP impacts on rivering aquatic health and drinking water quality, multimillion dollar modifications are underway at two of the major WWTPs. The primary goal of modification is to nitrify the effluent. This serves to decrease ammonium and oyygen demand but will increase nitrate concentrations in the effluent and river. Long term impacts of increasing nitrate concentrations in the river and drinking water are largely unknown. Preliminary data, including recent sampling of the 23 sites and more intensive sampling in the middle reach of the river near urban areas, provides insight into the evolution of river geochemistry before and after WWTP modification. *Keywords: Grand River, Geochemistry, Nutrients.*

MESQUITA, M.M.F., KOVAK, R., REZANEZHAD, F., and VAN CAPPELLEN, P., University of Waterloo, Ecohydrology Group, Department of Earth Sciences, 200 University Ave. West, Waterloo, ON, N2L 3G1. **DNA fingerprinting of sand bacterial populations from four Great Lake beaches by PCR-DGGE.**

Sand from coastal and inland beaches is often reported as a large repository of fecal indicator bacteria (FIB; *Escherichia coli* and *Enterococci*) and human pathogens. Monitoring for FIB using traditional cultural and molecular methods such as qPCR have limitations. A positive relationship between the risk for enteric illness and beach sand-contact activities as a function of FIB has been recently confirmed. This situation generates public health concern since the sanitary quality of beach sand is not enforced as part of most beach monitoring programs. Results of denaturing gradient gel electrophoresis (DGGE) for 16S rRNA targeted PCR amplified bacterial DNA gene sequences from sand bacterial populations in two rural and two urban Great Lake beaches are presented. Main contributions are:(1) recommendations for best sample size, sampling procedure, and DNA extraction protocol to ensure acceptable DNA yields from low biomass samples,(2) comparison of biodiversity and bacterial community distribution at various depths and beach locations in differently impacted beaches and(3) a better understanding of the role of sand characteristics and environmental conditions on the survival, replication and inactivation of sand bacterial populations, to facilitate decision making in beach management and public health protection *Keywords: Distribution patterns, PCR-DGGE, Bioindicators, Sandy beaches, Biodiversity, Public health.*

METCALFE, B.W.[1], JOHNSON, T.B.[1], and HOYLE, J.A.[2], [1]Ontario Ministry of Natural Resources, Aquatic Research and Monitoring Section, Picton, RR4, ON, K0K 2T0; [2]Ontario Ministry of Natural Resources, Lake Ontario Management Unit, Picton, RR4, ON, K0K 2T0. **Has the Feeding Behaviour of Lake Trout (*Salvelinus namaycush*) in Lake Ontario Changed In Response To Shifts In Prey Fish Community Composition?**

Lake trout in Lake Ontario have had a turbulent history. Once abundant, the species was considered extirpated from the lake by the early-1950s, became the focus of re-introduction efforts beginning in the late-1960s, and now exist at lower-than-desired abundance levels. Both native (sculpin, herring, *Mysis*) and non-native (alewife, rainbow smelt, round goby) lake trout forage fish abundances have undergone large fluctuations of their own. Changes in prey fish community composition can affect lake trout resource use, behaviour, and ultimately survival. To characterize feeding preference, we examined over 3,600 lake trout stomach contents since 2000. Diet results will be related to prey fish abundance, distribution, and how this may affect lake trout behaviour, energetics, and fitness. *Keywords: Lake Ontario, Lake trout, Diets.*

MIDWOOD, J.D.[1], VEILLEUX, M.A.N.[1], LAPOINTE, N.W.R.[1], PORTISS, R.[2], SCISCIONE, T.[2], WELLS, M.G.[3], DOKA, S.E.[4], and COOKE, S.J.[1], [1]Carleton University, Ottawa, ON; [2]Toronto Region Conservation Authority, Toronto, ON; [3]University of Toronto - Scarborough, Scarborough, ON; [4]Fisheries and Oceans Canada, Burlington, ON. **Winter biology of northern pike in a large urban embayment.**

In temperate freshwater ecosystems, winter is a critical time period that helps shape and structure aquatic communities. Despite the ecological importance of winter, practical challenges associated with sampling freshwater communities and observing individual behaviour have resulted in a knowledge deficit during this season. Winter is particularly important for northern pike (Esox lucius) populations since competition for resources is high, yet females must feed to support egg production. Given the importance of winter in the life history of northern pike and limited information for Laurentian Great Lakes, our primary goal is to describe winter habitat use within the embayments of Toronto Harbour by northern pike. Using an acoustic telemetry array we tracked the movements of 38 pike (mean length = 762 ± 148 mm) over three winters to evaluate residency, site fidelity, and intraspecific variability in habitat selection within Toronto Harbour. In addition, using temperature and pressure sensors integrated into the acoustic transmitters, we will evaluate the temperature and depth preferences of northern pike in winter. Results will improve our understanding of pike behaviour in a large urban embayment, and help direct future restoration activities targeted at improving winter habitat. *Keywords: Fish behavior, Wetlands, Fish tagging.*

MILAN, R.[1], WALSH, M.G.[2], CONNERTON, M.J.[3], SULLIVAN, P.J.[3], HOLDA, T.J.[1], RUDSTAM, L.G.[1], and HOLDEN, J.P.[4], [1]Cornell Biological Field Station/Department of Natural Resources, Cornell University, Bridgeport, NY, 13030; [2]USGS Lake Ontario Biological Station, Oswego, NY, 13126; [3]NY Department of Environmental Conservation, Lake Ontario Unit, Cape Vincent, NY, 13618; [4]Ontario Ministry of Natural Resources, Picton, ON, K0K 2T0. **Diel changes of vertical fish distribution in the Lake Ontario offshore: potential impact to utilization of the deep chlorophyll layer.**

Change in productivity of the Lake Ontario offshore caused shift in vertical structuring of lower trophic levels and increase in importance of the Deep Chlorophyll Layer (DCL). Most zooplankton are currently present in meta- and hypolimnetic water during summer. Do these shifts in the spatial structure of lower trophic levels affect fish distributions? We describe the diel vertical distribution of fish in the Lake Ontario offshore during summer (July - September 2013) and the biotic and abiotic factors most strongly influencing their vertical distribution (temperature, zooplankton distribution) as a part of larger project focused on

the vertical restructuring and DCL formation in Lake Ontario. Night gillnets catches were comprised mostly of alewife (98%) and confirmed the importance of this species for the offshore fish community. Alewife night time vertical distribution from gillnet catches were bimodal with one peak near the surface and the second in the lower epilimnion. Acoustic sampling confirmed this distribution pattern. During the day alewife schools were found deeper in the water than during the night and partly merged with the DCL layer. Therefore, alewife are likely feeding on zooplankton in the DCL during the day. *Keywords: Acoustics, Fish behavior, Lake Ontario.*

MILANI, D.J. and GRAPENTINE, L.C., Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **Prioritization of sites for sediment remedial action at Randle Reef, Hamilton Harbour.**

Randle Reef, Hamilton Harbour, has the largest volume of PAH contaminated sediment on the Great Lakes and will be undergoing a major remediation project. The project involves the construction of an engineered containment facility on top of the most contaminated sediment with sediments from other locations to be dredged and placed inside. The large volume of contaminated sediment involved required prioritization of areas to be dredged. Although benthic invertebrate community assessment can be the best indicator of in situ toxicity, this was problematic in the harbour due to lack of appropriate reference areas for comparison and potential effects of other stressors. Prioritization was therefore based on laboratory toxicity tests and the associated contaminant levels. In 2002, 80 sites were sampled and subject to whole-sediment toxicity testing with two benthic invertebrates. Priority subareas were established based on: 1) high contamination and toxicity; 2) high contamination and no/low toxicity and; and 3) low contamination and toxicity. Final prioritizations considered additional sediment data obtained to address data gaps as well as study design and area considerations. Of the 80 sites, 79% were classed as a priority subgroup. The remediation project is expected to remove 68% of the toxic sites and 99.6% of the PAH mass. *Keywords: Remediation, PAHs, Sediments.*

MILLER, C.J.[1], MYLLYOJA, R.[2], SEYMOUR, L.[3], and BABAKHANI, F.[1], [1]Dept. of Civil and Environmental Engineering, 5050 Anthony Wayne Drive, Wayne State University, Detroit, MI, 48202; [2]HRC, Inc., 555 Hulet Drive, Bloomfield Hills, MI, 48302; [3]Macomb County Public Works Office, 21777 Dunham Road, Clinton Township, MI, 48036. **Multi-Stage Ditch Design for Reduction of Sediment and Phosphorus Loads.**

Effective open channel design greatly reduces future maintenance needs and can improve channel stability and quality of the receiving waters. The adoption of sustainable drainage rules, with allowances for site-specific exceptions, could have tremendous beneficial impacts. Vegetation management guidelines that allow for vertically diverse native plant communities - trees, shrubs, and herbaceous understory would also reduce water temperatures, erosion and water quality degradation. Excessive growth of invasive shrubs can shade the banks and prevent understory growth which stabilizes the banks. Complete clearing of all woody plants can increase wind erosion, promote the growth of cattails or phragmites, and increase water temperatures. An integrated assessment is performed to facilitate the development of design criteria for open channel construction and restoration that optimizes environmental benefit, with a reduction in erosion and sediment loadings to receiving waters. *Keywords: Sediment control, Channel, Environmental policy, Ditch, Phosphorus.*

MILLER, D.H.[1] and ANKLEY, G.T.[2], [1]U.S. EPA, Mid-Continent Ecology Division, 9311 Groh Rd., Grosse Ile, MI, 48134; [2]U.S. EPA, Mid-Continent Ecology Division, 6201 Congdon Blvd., Duluth, MN, 55804. **Adverse Outcome Pathways Linked to Population Models as a Methodology for Investigating Effects of Chemical Stressors.**

In addressing the complexity and toxicity of chemical contaminants in Great Lakes ecosystems, we describe an approach to link chemically induced alterations in molecular and biochemical endpoints to adverse outcomes in whole organisms and populations. Analysis of population impacts of chemical stressors through the use of modeling provides a linkage between endpoints observed in the individual (i.e. through effects based monitoring) and ecological risk to the population as a whole. Our approach employs a simple density dependent logistic matrix model linked to adverse outcome pathways (AOPs) for reproductive effects in fish of contaminants that impact different points within the hypothalamic-pituitary-gonadal axis. As an example, quantitative relationships between estradiol, testosterone, and vitellogenin concentrations and fecundity established in fathead minnow *(Pimephales promelas)* 21-d reproduction studies with different HPG-active chemicals are used to forecast the effects on populations exposed to stressors that reduce vitellogenesis. A second example utilizes linked AOP and population models parameterized with long-term monitoring data for white sucker *(Catostomus commersonii)* collected from a study site at Jackfish Bay, Lake Superior to predict population trends over time, including after mitigation. *Keywords: Populations, Ecosystem modeling, Environmental contaminants.*

MILLIGAN, M.S.[1], RICHARDS, D.[1], CRIMMINS, B.S.[2], XIA, X.[2], HOPKE, P.K.[2], HOLSEN, T.M.[2], and PAGANO, J.J.[3], [1]SUNY Fredonia, Fredonia, NY, 14063; [2]Clarkson University, Potsdam, NY, 13699; [3]SUNY Oswego, Oswego, NY, 13126. **Identification of Environmental Degradation Products Potentially Derived from Legacy Pollutants and Emerging Contaminants in Great Lakes Fish Using GCxGC-TOF Mass Spectrometry.**

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 derived from legacy pollutants and/or emerging contaminants. Whole fish Lake Trout composites from all five Great Lakes were mixed, extracted, and cleaned-up using automated GPC and deactivated silica gel columns. Final extracts were then analyzed using comprehensive two-dimensional gas chromatography, coupled with time-of-flight mass spectrometry. Potential degradation products derived from abundant environmental contaminants, such as PCBs, PBDEs, and organochlorine pesticides, were predicted by running the University of Minnesota Biocatalysis/Biodegradation Database Pathway Prediction System. Targeted searching of the Wiley/NIST library database resulted in many potential hits, including chlorinated and brominated methoxyphenol and methoxybenzene isomers. Howard and Muir (2013) used a similar approach to identify potential stable degradation products derived from precursor compounds identified in their previously published list of 610 persistent and bioaccumulative in-use industrial chemicals (2010). Targeted searching for these compounds also resulted in potential hits in Great Lakes fish. *Keywords: Environmental contaminants, Great Lakes basin, Fish toxins.*

MILNE, J.E.[1] and GILPIN, S.[2], [1]Environment Canada, 867 Lakeshore Rd., Burlington, ON, L7R 4A6; [2]Parks Division, City of Hamilton, 77 James St. N., Suite 351, Hamilton, ON. **Hamilton Harbour Beaches: Towards de-listing 2020, Successes and Challenges.**

Previous to 1990 less than 5 % of the City of Hamilton's shoreline was accessible to the public. Support from various stakeholders including the Hamilton Harbour Remedial Action Plan (HHRAP) and the City of Hamilton lead to a number of successful remediation/implementation of projects including the construction of Pier 4 Park Beach and Bayfront Beach which officially opened in 1993. Pier 4 Beach and Bayfront Beach have experienced health advisory postings on a regular basis during the summer months where the E. coli has exceeded the Provincial Water Quality Objective (PWQO) of 100 cfu/ 100 ml. Wastewater was once considered to be the key source of E. coli contamination but recent studies have revealed fecal contamination by birds may be a significant source. In order to de-list as an AOC, the beaches must remain open for >80% of the swimming season. This presentation will discuss the history of the beaches as well as the successes and challenges in meeting the de-listing criteria by 2020. *Keywords: Hamilton Harbour, Beaches, Urban areas, E. coli.*

MINSKER, B.S.[1], WIETSMA, T.[1], and COLLINGSWORTH, P.[2], [1]3230d NCEL, MC-250, U. of Illinois Urbana-Champaign, Urbana, IL, 61801; [2]77 W. Jackson Blvd. (G-17J), Illinois-Indiana Sea Grant, UIUC Extension Liaison to U.S. EPA GLNPO, Chicago, 60604. **Algorithmic Detection of Thermoclines in Great Lakes Water Quality Data Using Signal Processing Methods.**

Detection and sampling of the thermocline during vertical water quality profiling is typically a manual process, where data from the downward profile are viewed graphically to identify the best locations for bottle sampling on the upward profile. This process could reduce replicability in different locations and increase variability across sampling operators. We have investigated the feasibility of using signal processing methods, including filtering, spectral analysis, and nonlinear regression, to automate the process of detecting the thermocline during sampling. The methods are developed and tested with temperature data collected by the Environmental Protection Agency from the Great Lakes using Sea Bird vertical profilers. The results indicate that the algorithms are highly effective at automatically identifying the thermocline and offer significant promise for enabling more consistent and rapid adaptive sampling. *Keywords: Monitoring, Signal processing, Data acquisition.*

MISTRY, R.J. and ACKERMAN, J.D., University of Guelph, 50 Stone Road East, Guelph, ON, N1G 2W1. **The Selective Feeding Behaviours of Adult and Juvenile Freshwater Mussels Under Flowing Conditions.**

Freshwater unionid mussels play a vital role in aquatic ecosystems, in particular, clarification of lakes and rivers, nutrient cycling and benthic-pelagic coupling. It remains to be determined as to whether and how selective feeding in unionids occurs under ecologically relevant flow conditions. Flow chamber experiments using adult Fatmuckets (Lampsilis siliquoidea; shell length = 9 - 12 cm) indicate that seston flux using river water affects their clearance rates. Clearance rate (CR) increased with chamber velocity (0-18 cm s-1) and CR at the highest flux were 5 time larger than under low or static flow conditions (i.e., 0.21 L h-1). Preliminary data on juvenile Wavyrayed lampmussel (Lampsilis fasciola; shell length 430 - 580 µm) using a newly developed paddle-wheel flow chamber indicate that high seston flux reduce CR from 1.39 mL hr-1 at 0 cm s-1 to 0.39 mL hr-1 at 8 cm s-1). Data, obtained using flow cytometry techniques (FlowCam) are being analyzed to determine whether there is selectivity based on particle size and/or food quality. Results will provide information on habitat requirements of unionid mussels, their role in the great Lakes Ecosystem, and insight into their conservation. *Keywords: Hydrodynamics, Selective Feeding, Mussels, Fish behavior.*

MOFIDI, M.A. and KALANTARI, M.S., Sharif University of Technology, Azadi Street, Tehran, Iran. **Numerical study of the flow pattern around the bridge pier in 180 degrees curved channel.**

Natural rivers flow direction are rarely straight ones which necessitate studying flow in a curved or turned channel. The curvature simulates river morphology much more realistically. The objective in a curved open channel is secondary flows and vortexes. In this survey, discharge and pier location, effects are investigated in a 180-degree-curve channel. Flow pattern and currents analyzed through different position of bridge pier and flow rate. Ratio of the channel radius to its width is 4.67. In order to model different stream circumstance several flow discharges (namely 24,28,30 and 32 liter per second) are considered. The pier is positioned at different angle starting from 0 degree, beginning of the curvature, to 180 degrees ,where it finished, with 30 degrees interval. Thoroughly, the pier is employed at 0, 30, 60, 90,120,150 and 180 angels.The results show a decelerated velocity region at intersection of center line of the channel and downstream of the pier. Although a high velocity region is occurred between pier and inner wall of the channel. Iso velocity lines confirm these facts. The variation trend of the velocity regions in other flow rates were the same but different in magnitude. Secondary flows and prier were the main reasons for these variations. *Keywords: Computer models, Bridge pier, Boundaries, Fluent, Bottom currents.*

MOHAMED, M.[1], CHOMICKI, K.M.[2], and LONG, T.L.[1], [1]Ontario Ministry of the Environment, 125 Resources Rd, Toronto, ON; [2]Toronto and Region Conservation Authority, 5 Shoreham Dr, Downsview, ON, M3N 1S4. **Winter, Spring, Summer, Fall - Why does season matter to loadings at all? A synthesis of the current issue.**

It has been appreciated for some time that, in temperate regions, there is seasonal variability in stream discharge, nutrient, and sediment loadings, with the observed pattern driven by seasonal patterns in evapotranspiration and precipitation (both amount and nature). However, the accepted paradigm of this seasonal pattern for streams in southern Ontario may not reflect the reality of how discharge, nutrient, and sediment loadings actually occur throughout the seasonal cycle. Typically, monitoring programs and sometimes even studies of annual nutrient and sediment loading from streams ignore periods that are important in understanding the magnitude and potential impact of stream nutrient and sediment loading. We examine the accepted view of the pattern of stream discharge, nutrient, and sediment loading for streams in southern Ontario and compare this to available information from a variety of recent studies. The potential consequences of this revised understanding will be discussed, as well as aspects of nutrient and sediment loading in need of further study to improve our understanding of the potential impacts on the Great Lakes. *Keywords: Nutrients, Loading, Sediment load, Season, Zooplankton, Hydrograph.*

MOHR, L.C.[1], EBENER, M.P.[2], and JOHNSON, J.E.[3], [1]Upper Great Lakes Management Unit, Ontario Ministry Natural Resources, 1450 Seventh Avenue East, Owen Sound, ON, N4K 2Z1; [2]Chippewa Ottawa Resource Authority, 179 West Three-Mile Road, Sault Ste. Marie, MI, 49783; [3]MI - DNR Alpena Fisheries Research Station, 160 E. Fletcher Street, Alpena, MI, 49707. **Changing Commercial Fisheries and Fish Communities in Lake Huron. Are they Related?**

Commercial fisheries in Lake Huron have changed dramatically in some parts of the lake while not in others. Areas which have seen the largest changes in fish community have seen the largest changes in commercial fisheries. Lake whitefish once dominated the commercial fishery in Lake Huron and while it still makes up the majority of the catch, other native species appear to be becoming more common in this fishery. The yellow perch fishery in the southern main basin, for example, is approximately four times larger than it was prior to the alewife collapse in 2004. Conversely, lake whitefish harvests in the northern main basin, Ontario waters, have declined by over 70% from a peak just prior to the Alewife collapse. Several factors including ecological and population changes have contributed to changes in the commercial fishery. *Keywords: Species composition, Fisheries, Lake Huron.*

MOLEN, N., BROOKS, C.N., SHUCHMAN, R.A., SAYERS, M., JESSEE, N., and ENDSLEY, K.A., Michigan Tech Research Institute, 3600 Green Ct., Ste. 100, Ann Arbor, MI, 48105. **Extending Great Lakes Remote Sensing Products to Stakeholders through GLOS, Coastwatch, and Custom Portals.**

Our research team has been working closely with the Great Lakes Observing System and NOAA Great Lakes Coastwatch to make derived remote sensing products for the region more widely available. Through a combination of custom portals, standardized data sharing methods, appropriate metadata, and useful symbolization, these data have become

more available over the past year. At MTRI's "Satellite-Derived Great Lakes Remote Sensing" portal (http://www.greatlakesremotesensing.org/), MTRI Color Producing Agent Algorithm (CPA-A) products such as chlorophyll, dissolved organic carbon, and suspended minerals can be viewed for the satellite cloud-free season (usually April - October). An approval process is underway with NOAA to make these data available for display and download through the Great Lakes Coastwatch node. The new GLOS Data Portal has been working through its Data Management and Communications (DMAC) committee to make the most recent natural color, temperature, chlorophyll data available, along with recent Ranger III ship-based data and optical properties information. Through this collaboration, Great Lakes decision makers, researchers, the public, and other stakeholders have greater access to critical regional data derived from remote sensing data sources. *Keywords: Observing systems, Outreach, Remote sensing.*

MOLOT, L.A.[1], WATSON, S.B.[2], CREED, I.[3], TRICK, C.G.[3], MCCABE, S.K.[4], VERSCHOOR, M.J.[4], SORICHETTI, R.J.[3], POWE, C.[4], VENKITESWAN, J.J.[5], and SCHIFF, S.L.[5], [1]Faculty of Environmental Studies, York University, Toronto, ON, M3J 1P3; [2]Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6; [3]Dept of Biology, Western University, London, ON, N6A 5B7; [4]Dept of Biology, York University, Toronto, ON, M3J 1P3; [5]Earth and Environmental Sciences, University of Waterloo, Waterloo, ON, N2L 3G1. **A novel model for cyanobacteria bloom formation: the critical role of anoxia and ferrous iron.**

A novel conceptual model linking anoxia, phosphorus (P), nitrogen (N), iron (Fe) and sulfate to the formation of noxious cyanobacteria blooms is presented that reconciles seemingly contradictory ideas about the roles of P, N and Fe in bloom formation (Molot et al. 2014, Freshwater Biology). The model has several critical concepts: (1) P regulates biomass and productivity in freshwaters until excessive loading renders a system N-limited or light-limited but it is the availability of ferrous iron (Fe2+) that regulates competition between cyanobacteria and its eukaryotic competitors; (2) Fe2+ diffusing from anoxic sediments is a major Fe source for cyanobacteria, which acquire it by migrating downwards into Fe2+-rich anoxic waters from oxygenated waters; and (3) subsequent cyanobacterial siderophore production provides a supply of Fe3+ for reduction at cyanobacteria cell membranes that leads to very low free Fe3+ concentrations in the mixing zone. When light and temperature are physiologically suitable for cyanobacteria growth, bloom onset is regulated by the onset of internal Fe2+ loading which in turn is controlled by anoxia, reducible Fe content of surface sediments and sulfate reduction rate. This model can be applied to polymictic sys-

tems such as inshore areas in the Great Lakes where cyanobacteria blooms may originate. *Keywords: Cyanophyta, Phosphorus, Eutrophication, Ferrous iron, Nutrients, Anoxia.*

MONTENERO, M.P. and WAPLES, J.T., University of Wisconsin- Milwaukee, 600 E. Greenfield Ave., Milwaukee, WI, 53204. **Iodine-131: a novel tracer for Milwaukee sewage effluent in nearshore Lake Michigan.**

Iodine-131 (half-life: 8.02 days) is a common radiopharmaceutical used in diagnostic and treatment procedures. It is effectively eliminated from the body in the patient's waste stream. In municipal systems, $^{131}$I activity is largely unaffected by sewage treatment and it is ultimately released to the environment. From measurements of $^{131}$I in treated sewage effluent by gamma spectroscopy and measured effluent discharge, we calculate that, during the months of July and August (2013), the Milwaukee Jones Island and South Shore treatment plants release a combined average of $(2.5 \pm 1.2) * 10^8$ Bq d$^{-1}$ of $^{131}$I to nearshore Lake Michigan. A survey of 24 km of Milwaukee shoreline revealed measurable activities of $^{131}$I in *Cladophora* algae (~0.014 Bq g$^{-1}$) and dreissenid mussels (~0.14 Bq $^{g-1}$) and provides unequivocal evidence of recent exposure to treated sewage effluent. $^{131}$I can be used to map wastewater flow in Lake Michigan over short time scales and can serve as a proxy for nutrients or contaminants of emerging concern (e.g., pharmaceuticals) that enter the lake through effluent discharge. *Keywords: Wastewater, Radioisotopes, Pollutants.*

MORRIS, J.M., USGS, 6480 Doubletree Avenue, Columbus, OH, 43228. **USGS Beach-Health Investigations Throughout the Great Lakes - A Summary of Work from 2008-2014.**

Scientists with the U.S. Geological Survey (USGS) have been working on research related to beach health for well over a decade. The overall mission of this work is to provide science-based information and methods that will allow beach managers to more accurately make beach closure and advisory decisions, understand the sources and physical processes affecting beach contaminants, and identify how to apply research to mitigate fecal contamination, restore beaches, and protect the public. Current work consists of four science elements: (1) expanding the use of and improving real-time assessments, (2) testing and applying methods for pathogens and source-tracking markers, (3) understanding coastal processes that influence indicator and pathogen concentrations, including identifying physical and biological factors that contribute to recreational water quality along extended shoreline areas, and (4) improving Great Lakes-wide beach-data analysis, interpretation, and communication.

Funding for USGS beach research comes from a variety of sources, and collaborations with local and state agencies are considered a key to the success of applying research to address real problems and provide relevant solutions to USGS partners. This presentation will provide an overview of the work completed as part of this effort since 2008. *Keywords: Human health, Decision making, Coastal processes.*

MORRISON, A.M., HOOD, J.L.A., SCHIFF, S.L., and TAYLOR, W.D., University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L 3G1. **Assessing the Use of Stable and Radioisotopes to Study Phosphorus Cycling in the Grand R.**

Phosphorus (P) plays a decisive role in the eutrophication of logic systems. It is often the limiting nutrient in freshwater bodies, meaning its availability can control rates of plant and algal growth. Anthropogenic P inputs include waste water treatment plant (WWTP) effluent, and agriculture which act as major P sources to highly impacted rivers. The Grand River lies in the largest Canadian watershed feeding into L. Erie with a population of almost 1 million people, and 30 WWTPs. The ability of the river to assimilate the surplus of P delivered by these plants is unclear, as is the fate of further P increases brought on by the expected population increase in the watershed. Two approaches were used to examine P cycling, and the effect of source inputs on uptake length downstream of the Waterloo and Kitchener WWTPs. $^{32}$P incubations with seston and epilithon were used to determine $PO_4$ turnover time and uptake length. A model was used to predict the change in $\delta^{18}O\text{-}PO_4$ in order to examine the expected return to isotopic equilibrium on a watershed scale. These two methods provide valuable insight on the rates of biological uptake, release, and the in-stream processes that alter the delivery of P to L. Erie. *Keywords: Eutrophication, Phosphorus, Isotope studies.*

MOSTAFA, A.[1], HELM, P.[2], MACARTHY, L.[1], YANG, P.[2], and MORSE, D.[2], [1]Department of Chemistry and Biology, Ryerson University, Toronto, ON, M5B 2K3; [2]Ontario Ministry of the Environment, 125 Resources Road, Etobicoke, ON, M9P 3V6. **Determination of Contaminants of Emerging Concern Using POCIS Sampler and UHPLC-Orbitrap Mass Spectrometry.**

Chemicals discovered in the environment that had not previously been detected or are detected at unexpected levels are generally referred to as contaminants of emerging concern (CECs). They may pose potential threats to human health and the environment. Sensitive, selective and reliable analytical methods are required to monitor CECs in complex environmental matrices. We present a new analytical workflow that was applied in the quantitative analysis of 52 CECs and the identification of > 382 non-target analytes including degradation by-products as collected by polar organic chemical integrative samplers (POCIS). POCIS collected from surface water and wastewater treatment plant effluents entering the Great Lakes were ultrasonically extracted and analyzed as is using ultrahigh performance liquid chromatography (UHPLC) coupled to a high resolution Orbitrap mass spectrometry for qualitative and quantitative determination of the targeted and non-targeted analytes. Full scan, high resolution Orbitrap MS data was processed by TraceFinderTM with a compound database for non-targeted analysis as well as quantitative analysis of CECs. This method eliminates matrix effects observed in other analyses and provided both quantitative results for 52 targeted compounds and occurrence and semi-quantitative data for 382 non-targeted compounds. *Keywords: Chemical analysis, Mass spectrometry, Pollutants.*

MUMBY, J.A.[1], YUILLE, M.J.[2], JOHNSON, T.B.[2], STEWART, T.J.[2], and FISK, A.T.[1], [1]Great Lakes Institute for Environmental Research, University of Windsor, 401 Sunset Avenue, Windsor, ON, N9B 3P4; [2]Ontario Ministry of Natural Resources, Glenora Fisheries Station, 41 Hatchery Lane, R.R. #4, Picton, ON, K0K 2T0. **Non-complementary foraging behaviour of Lake Ontario salmonid species.**

Lake Ontario has a number of native (Lake Trout & Atlantic Salmon) and non-native (Chinook Salmon, Coho Salmon, Rainbow Trout & Brown Trout) salmonids, established and largely maintained by stocking. Management goals to maintain highly-valued recreational fisheries by stocking non-native salmonids and to also restore native salmonids raises concerns about the potential for prey resource limitation among salmonids. The objectives of this study was to quantify the diet and trophic position of Lake Ontario salmonids, collected in 2012 and 2013, using stable isotopes (C & N) and stomach contents, and to quantify isotopic niche dimensions (40% ellipses) and overlap between species. Lake Trout had the largest isotopic niche space and the highest trophic position based on δ15N. Coho Salmon had the smallest niche dimensions with little overlap with Chinook Salmon, Rainbow Trout and Brown Trout. Large niche overlap was observed in Brown Trout and Chinook Salmon while Rainbow Trout had a broad vertical (δ15N) niche, suggesting feeding across trophic levels. Despite similar stomach contents, stable isotopes suggest that non-native salmonids do not compete with Lake Trout in Lake Ontario but a further detailed analysis on the isotopic signatures of Lake Ontario prey species will be required. *Keywords: Lake Ontario, Diets, Stable isotopes, Trout, Salmon, Niche dimensions.*

MUMBY, J.A.[1], JOHNSON, T.B.[2], STEWART, T.J.[2], and FISK, A.T.[1], [1]Great Lakes Institute for Environmental Research, University of Windsor, 401 Sunset Avenue, Windsor, ON, N9B 3P4; [2]Ontario Ministry of Natural Resources, Glenora Fisheries Station, 41 Hatchery Lane, R.R. #4, Picton, ON, K0K 2T0. **Spatial variation in isotopic signatures of important prey fishes in Lake Ontario.**

Quantifying the feeding ecology of large, mobile top predators is a key component of understanding ecosystem structure and developing sound management plans for large lakes. Stomach contents and stable isotopes are the main tools for quantifying fish diets but they can produce conflicting interpretations. Physico-chemical properties of large lakes (e.g., bathymetry, mixing, and watershed inputs) may influence the stable isotopes of forage fish and could explain discrepancy between methods observed in Great Lakes salmonids. To explore this question, we analyzed dominant prey fishes (Alewife, Round Goby, Rainbow Smelt, Deepwater Sculpin & Slimy Sculpin) from Lake Ontario to assess temporal and spatial patterns (April to November) of stable isotopes (C & N) and determine trophic discretness along a horizontal (nearshore vs. offshore) and vertical (pelagic vs. demersal) gradient. Preliminary data suggests δ13C values were similar for both nearshore, offshore, and benthic Alewife and Rainbow Smelt, and to a lesser extent, Round Goby. Rainbow Smelt, Deepwater Sculpin, and Slimy Sculpin had the highest δ15N values compared to Round Goby and Alewife. Understanding spatial and temporal variability in prey fish isotopic signature will improve analyses of top predator feeding ecology. *Keywords: Stable isotopes, Spatial patterns, Fish, Niche space, Lake Ontario, Bathymetric zones.*

MUNAWAR, M.[1], FITZPATRICK, M.[1], and KLING, H.[2], [1]Fisheries & Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6; [2]Algal Taxonomy & Ecology, Winnipeg, MB, R3T 2X8. **Characteristics of Algal Blooms in Hamilton Harbour and Bay of Quinte Areas of Concern.**

Eutrophication is one of the major beneficial use impairments affecting Hamilton Harbour and other Remedial Action Plan sites. While algal blooms have been a common sight in the harbour and the link to phosphorus loads has been well established, little effort has been made to characterize the structure and function of individual bloom events. One such bloom event occurred in Hamilton Harbour during the summer of 2006 when the bay was sampled extensively and spatially (12 stations). During this bloom, chlorophyll a concentrations of 20 - 30 ug/l were observed and phytoplankton biomass ranged 3 - 12 g/m3. *Woronichinia naeglianum* was the most dominant species observed. A comparison of Hamilton Harbour with the Bay of Quinte provides some interesting information about the nature and

composition of algal blooms. A spatial survey of the Bay of Quinte during the summer of 2010 revealed that the composition of the bloom was not the same across the bay. It varied spatially with cyanobacteria and diatom blooms occurring at different sites. This contrasts the almost unialgal composition observed in Hamilton Harbour. There is a great need to explore the structure and function of algal blooms in detail going beyond chlorophyll and nutrient measurements. *Keywords: Cyanophyta, Diatoms, Eutrophication.*

MUNUBI, R.[1], VADEBONCOEUR, Y.[1], and MCINTYRE, P.B.[2], [1]Department of Biological Sciences, 3640 Colonel Glenn Highway, 235A, BH, Wright State University, Dayton, OH, 45435; [2]Center for Limnology & Dept. of Zoology, University of Wisconsin, 680 North Park St., Madison, WI, 53706. **Depth Distribution of Algivorous Cichlid Fish in Relation to Algal Food Resources in Lake Tanganyika.**

Algivorous cichlids dominate the fish assemblages of the rocky shores of the East African great lakes. We quantified densities and depth distribution of the two dominant algivores in Kigoma region of Lake Tanganyika from 0 to 8 m depth at 12 rocky littoral sites. We also measured rugosity, periphyton phosphorus content, and primary productivity at each site. Fish densities were highest at 0.5 to 3 m depth and decreased exponentially with depth. Periphyton productivity and P-content also declined with depth. Among sites, fish density and algal P-content were significantly positively correlated, but fish densities were only weakly correlated with among-site variation in rugosity and primary productivity. Algivores inhabited the shallowest water where light intensity and primary productivity is highest, suggesting a strong effect of food availability on algivore distribution. Although the modest among-site variation in periphyton productivity was not a good predictor of algivore densities, a negative correlation between fish density and ash content of fish feces suggests that increased sedimentation associated with deforestation negatively affects algivores in Lake Tanganyika. Overall, we conclude that algivorous cichlids track their food resources strongly with respect to water depth and weakly with respect to shoreline location. *Keywords: Fish, Lake Tanganyika, Distribution patterns.*

MURPHY, E.W.[1], WELLENKAMP, W.[5], JOHNSON, J.E.[2], HOLSEN, T.M.[3], CRIMMINS, B.S.[3], HOPKE, P.K.[3], PAGANO, J.J.[4], and MILLIGAN, M.S.[5], [1]U.S. Environmental Protection Agency, 77 W. Jackson Blvd, Chicago, IL, 60604; [2]MI - DNR Alpena Fisheries Research Station, 160 E. Fletcher, Alpena, Mi, 49707; [3]Clarkson University Department of Civil and Environmental Engineering, PO Box 5710, Potsdam, NY, 13699-5725; [4]SUNY

Oswego, 8C Snygg Hall Washington Blvd., Oswego, NY, 13126; [5]SUNY Fredonia Department of Chemistry, 218 Houghton Hall, Fredonia, NY, 14063. **Contaminant Concentrations of Lake Trout: Are They Affected by Changes in Growth as a Function of the Changing Food Web?**

The Michigan Department of Natural Resources (MiDNR), Alpena Fisheries Research Station, is employing a new aging technique that may be better able to determine age quickly using the maxillary bone of lake trout as opposed to relying solely on more traditional methods. This new method can be performed with a high level of accuracy and rapidly enough that fish could be grouped into the appropriate age class prior to homogenization into composites according to the Great Lakes Fish Monitoring and Surveillance Program's (GLFMSP) Standard Operating Procedures (SOP). Additionally, the maxillary bone is particularly useful for this application because its removal is non-intrusive (thus not significantly affecting whole-body contaminant results) and suitable for ageing long-lived, slow growing lake trout. The GLFMSP and the MiDNR are confirming this aging technique by determining fish age, through the new method and a traditional method, from two independent labs. Fish age will be used to help explain the changes in fish tissue concentration for some legacy contaminants in Lake Huron lake trout collected as part of the long term GLFMSP. Results of this collaboration may alter the standard collection procedures for the GLFMSP into the future for Lake Huron and / or other Great Lakes to better reflect the environmental condition. *Keywords: Lake Huron, Chemical analysis, Fish.*

MURRAY, M.W.[1], DEBARROS, C.[2], KRANTZBERG, G.[3], RIDAL, J.[4], and SWACKHAMER, D.L.[5], [1]National Wildlife Federation, 2812 Joy Rd., # 113, Augusta, GA, 30909; [2]Toronto and Region Conservation Authority, 70 Canuck Avenue, Toronto, ON, M3K 2C5; [3]McMaster University,ETB 510, 1280 Main St. W, Hamilton, ON, L8S 4L7; [4]St. Lawrence River Institute of Environmental Sciences, 2 St. Lawrence Drive, Cornwall, ON, K6H 4Z1; [5]Water Resources Center, 173 McNeal Hall, University of Minnesota, 1985 Buford Avenue, St Paul, MN, 55108. **Re-evaluation of Indicators of Toxic Chemicals in the Great Lakes.**

The International Joint Commission coordinated a process in 2012-13 to identify a limited number of ecosystem indicators that might be useful in most succinctly describing the state of the Great Lakes and help assess progress of the U.S. and Canadian Governments toward meeting objectives of the Great Lakes Water Quality Agreement (GLWQA). As part of this indicator project, two workgroups examined existing efforts and developed recommendations addressing toxic chemicals in biota and water. In the end, indicators identified as

priorities were persistent, bioaccumulative and toxic (PBT) chemicals in selected whole fish species and fish-eating birds, and concentrations of selected legacy chemicals of mutual concern (CMC) and chemicals of emerging concern in water. Issues considered in identification of these indicators included relevance to the new GLWQA, ongoing monitoring/indicator efforts, sampling and analytical feasibility, potential representativeness of the broader biotic community for PBT chemicals in biota, and the need for additional efforts to identify chemicals of emerging concern for focus in the CMC in water indicator. This presentation will explore these and other issues important in developing indicators and implementing programs to assess and manage toxic chemicals in the Great Lakes. *Keywords: Indicators, Environmental contaminants, Monitoring.*

MUSIC, B. and FRIGON, A., Ouranos - Consortium on Regional Climatology and Adaptation to Climate Change, 550 Sherbrooke W., Montreal, QC, H3A 1B9. **Water and Energy Budgets of the Great Lakes as Simulated by Regional Climate Models.**

Increasing temperatures over the Great Lakes surface and the surrounding land, accompanied by decreasing ice cover and duration, cause an important intensification of evaporative loss from the lakes. Results from RCM simulations suggest that stronger lake evaporation in the future climate may lead to significant decrease in Great Lakes water levels during late summer and fall. Evaporation is a complex hydrological process that couples the dynamics of the water and energy cycles over a given region. To get a comprehensive picture of the various factors driving evaporation from the Great Lakes, an analysis of energy and water budgets will be performed using multiple RCM simulations. The tight connection between energy and water cycles will be discussed. *Keywords: Atmosphere-lake interaction, Climate change.*

# N

N'GUYEN, A., HIRSCH, P.E., KALCHHAUSER, I., and BURKHARDT-HOLM, P., Program Man-Society-Environment, Dept. of Environmental Sciences, University of Basel, Vesalgasse 1, Basel, BS, 4051, Switzerland. **Potential economic impacts of a goby invasion.**

The Ponto-Caspian Gobiid species *Neogobius melanostomus* spreads across North-America and Europe. In 2012, *N. melanostomus* was first recorded in the Rhine near Basel, Switzerland. To investigate its economic impact on recreational angling and commercial fishing caused by habitat and food resource competition with native aquatic communities, a field study in the local harbour was conducted. The results indicate that non-native gobies display rapid population growth and build up high densities, and that their food niche possibly overlaps with roach, ruffe, and perch < 15 cm TL. Additional data from invaded water bodies in Germany suggest that changes in the fish community structure led to angler frustration, which presumably caused a decrease in fishing licence sales. Based on these findings, the potential financial impacts to the sectors of recreational angling and commercial fishing in currently uninvaded Lake Zurich area (total surface area 88 $km^2$, water volume 3.9 $km^3$) were calculated using four different scenarios for each sector. It can be expected that a goby invasion could lead to potential annual losses of 7'500 - 95'000 USD in the recreational angling sector and 30'000 - 380'00 USD in the commercial fishing sector in this area. *Keywords: Invasive species, Economic impact, Round goby.*

NAKHAEI, N.[1], BOEGMAN, L.[1], and BOUFFARD, D.[2], [1]Queens University, 58 University Av, Kingston, ON, K7L 3N6; [2]EPFL ENAC IIE APHYS GR A2 434 (Bâtiment GR), Lausanne, Switzerland. **Modelling sediment oxygen demand in stratified lakes.**

Numerous lakes in Canada are threatened by low oxygen (hypoxia). Observations show analogous hypoxic development in lakes with similar depth but varying size and trophic state (e.g., Lake Erie, Lake Simcoe and Eagle Lake). In this study, we comparatively investigate hypoxia development in these lakes. We develop a simple analytical model for oxygen depletion by least-squares-fitting to oxygen observations to estimate the sediment and hypolimnetic oxygen demands (SOD and HOD, respectively). The model is validated with a mass balance, applied to the hypolimnion, using observations of SOD, thermocline flux and oxygen advection. Future work will extend the model to generalize the effects of depth and trophic state on hypoxia development. *Keywords: Water quality, Oxygen, Sediments.*

NANDAKUMAR, H., ARTEAGA, R., PENDEA, F., KANAVILLIL, N., and KURISSERY, S., Lakehead University Orillia campus, 500 University Avenue, Orillia, ON, L3V 0B9. **Aerobic and anaerobic bacterial load in NW Lake Simcoe wetland sediments as an indicator of anthropogenic disturbance.**

The microbial distribution of aerobic and anaerobic bacteria in the redox continuity layer was investigated in NW Lake Simcoe wetlands, ON during fall 2013. Sediment cores (15" long) and surface water samples were collected from 6 wetlands exposed to varying levels of anthropogenic activities. Sub-samples at 3" intervals were extracted and used to determine aerobic and anaerobic microbial density by following standard culturing techniques. Hydrological as well as sediment parameters were measured to observe the relationship between these variables and the microbial load. The results showed a decrease in aerobic microbial density with sediment depth. This trend followed that of the DO of sediment porewater. In contrast, the anaerobic bacterial density increased in majority of the sites, with the lowest values observed at the surface, and the highest at the deepest core area. Anaerobic counts showed opposite trend to DO; the counts increased when DO decreased. In general, sites exposed to anthropogenic activities tend to show increased anaerobic counts, while aerobic counts remained relatively stable. Sites with lower levels of anthropogenic activities illustrated stable/slightly declining levels of anaerobic bacteria across the core indicating the possibility of using microbes as bioindicator of wetland disturbance. *Keywords: Bioindicators, Aerobic and anaerobic bacteria, Microbiological studies, Wetland sediment core analysis, Sediments.*

NASSAR, M.[1], CHOMICKI, K.M.[1], BOWEN, G.S.[1], and CUMMING, S.M.[2], [1]Toronto and Region Conservation Authority, 5 Shoreham Dr, Downsview, ON, M3N 1S4; [2]Cumming+Company, 427 Princess Street, #427, Kingston, ON, K7M 5S9. **Educating the public on nearshore water quality: strategies to engage, educate, and share data.**

Toronto and Region Conservation Authority (TRCA) has monitored the nearshore (NS) water quality of Lake Ontario by Western Durham since 2007. This region contains 4 main creeks, the Pickering Nuclear Generating Station and the Duffin Pollution Control Plant outfall. With many potential nutrient sources and a community concerned about algae, water quality is a contentious topic. The TRCA wanted to understand the existing water quality, and find a way to provide a balanced perspective of existing conditions to the community. Using their nutrient data and MOE's physical data, TRCA summarized water quality patterns in the lake NS and determined the importance of lake physics to these patterns. A public information session was organized which distilled a large amount of technical information highlighting important aspects of NS water quality in the region. Field, lab, and water quality personnel were on hand to answer questions at an open house prior to presenting the main findings. The TRCA has created a website that provides more detail on the water quality in the NS. Inherent is the challenge of conveying technical information to build awareness and understanding of what the information means to people's lives. This talk will review communication materials used, approaches for effective community engagement and lessons learned. *Keywords: Nutrients, Outreach, Water quality, Education, Lake Ontario.*

NAWROCKI, B., DELPAPA, J., SOULLIERE, A., SOULLIERE, J., and FISK, A.T., GLIER, London Life Great Lakes Environmental Research Centre, 2990 Riverside Drive West, Windsor, ON, N9C 1A2. **Niches and Trophic Positions of Predatory Fish Species in the Lower Huron-Erie Corridor.**

Top predators are indicators of ecosystem stability. Examining niche overlap and trophic positions between top predators is useful in evaluating how top predators co-exist and if functional redundancy exists. The Great Lakes has a significant number of predatory fish yet how these species co-exist and whether there is niche overlap between these species has received little attention. Lake St. Clair and the Detroit River have a variety of predators such as Longnose Gar (*Lepisoteus osseus*) and Northern Pike (*Esox lucius*) that are integral to the food web and provide a system for studying niche overlap in freshwater predators. The objective of this study is to quantify niche width and overlap of top predators in the lower Huron-Erie Corridor using stable isotopes in a number of tissues (muscle, liver, stomach and plasma) to determine the influence of season, year and space on diet and carbon sources. Preliminary results indicate that the isotopic niche of top predators is influenced by year and location. Isotopic niches suggest top predators have varying degrees of overlap and the potential to feed at a range of trophic positions. The results of this research will more clearly define the ecological role, the potential for niche overlap and competition, and if functional redundancy is relevant in the Great Lakes. *Keywords: Trophic level, Trophic position, Isotope studies, Food web, Predation.*

NEESON, T.M.[1], JANUCHOWSKI-HARTLEY, S.R.[1], GUYETTE, M.Q.[1], DIEBEL, M.W.[2], DORAN, P.J.[3], FERRIS, M.[4], O'HANLEY, J.R.[5], and MCINTYRE, P.B.[1], [1]Center for Limnology, University of Wisconsin, Madison, WI; [2]Wisconsin Dept. of Natural Resources, Madison, WI; [3]The Nature Conservancy, Lansing, MI; [4]Computer Sciences, University of Wisconsin, Madison, WI; [5]Kent Business School, University of Kent, Canterbury, UK. **Prioritizing barrier removals to restore native fish migrations in Great Lakes tributaries.**

Tributaries to the Great Lakes are highly fragmented by dams and road crossings that act as potential barriers to migratory fishes, restricting their access to historical riverine spawning grounds. The removal or modification of barriers can restore migratory pathways for these species, but removal costs and habitat gains differ markedly among potential projects. In the Great Lakes basin, the restoration community lacks a systematic method for comparing these costs and benefits to assess which barrier removal projects would offer the greatest return on investment. To address this problem, we developed a basin-scale mathematical optimization model to prioritize barriers for repair/removal on the basis of upstream breeding habitat. We found that the amount of accessible breeding habitat in the basin can be doubled for an investment of about $80m, a dollar amount well within the range of recent spending on Great Lakes restoration projects. That scenario would involve the removal or upgrade of numerous road crossings and a number of key problematic dams. We will discuss key factors that drive barrier prioritization, spatial patterning of priority projects, and future plans to incorporate invasive species (sea lampreys, gobies) into the model. *Keywords: Tributaries, Dams, Migrations, Road crossings, Conservation, Restoration.*

NEFF, M.R.[1], BHAVSAR, S.P.[1], NI, F.J.[2], CARPENTER, D.O.[3], DROUILLARD, K.G.[4], FISK, A.T.[4], and ARTS, M.T.[5], [1]Ontario Ministry of the Environment, Toronto, ON; [2]University of Toronto, Toronto, ON; [3]University at Albany, Rensselaer, NY; [4]University of Windsor, Windsor, ON; [5]Environment Canada, Burlington, ON. **Risk-benefit of consuming Lake Erie fish.**

Fish consumption is promoted as a healthy way to obtain essential fatty acids in the diet, yet the risk of ingesting harmful contaminants remains a concern. At present, the risks and benefits of consuming fish from the Great Lakes, which sustain important commercial and recreational fisheries, are unclear. We report the concentration of contaminants and beneficial fatty acids in 146 skinless fillets of 15 fish species from Lake Erie and assess whether recommended fatty acid dietary requirements can be met by safe fish consumption. A simulated consumption advisory (maximum recommended number of meals per month) was calculated for each sample, and used to calculate the maximum amount of beneficial fatty acids (EPA+DHA) that would be consumed if the advisory was followed. Large, fatty species had the highest EPA+DHA content, but had the most restrictive advisories due to high PCB concentrations. To minimize contaminant exposure while maximizing EPA+DHA intake, consumers should consider small lake whitefish and lake trout, small panfish species, and/or walleye. While very few species had EPA+DHA content sufficient to safely meet the highest dietary guidelines, consumption of certain Lake Erie fish, within the limits of our simulated fish consumption advisories, can be a good supplemental source of beneficial fatty acids. *Keywords: Fish, Human Health, Environmental contaminants, Risk-Benefit, Lake Erie, Fish Consumption.*

NESBITT, R.A.[1], KRANTZBERG, G.[2], HUTCHINSON, N.J.[1], and JETOO, S.[2], [1]Hutchinson Environmental Sciences Ltd., 202-501 Krug St., Kitchener, ON, N2B 1L3;

[2]McMaster University, 1280 Main St W., Hamilton, ON, L8S 4L8. **The State of Urban Phosphorus Management in the Lake Erie Basin.**

Environment Canada's September 2012 Great Lakes Nutrient Initiative focuses on understanding nearshore water quality and its relationship to nuisance algae blooms and anoxia in Lake Erie. One of the priorities is to develop policy options and strategies to meet phosphorus reduction targets. HESL was contracted to review existing regulatory and voluntary policies, programs and legislation related to reducing inputs of phosphorus to Lake Erie from urban and rural communities. The review identified and assessed programs within the Canadian and USA portions of the Lake Erie watershed as well as other Great Lakes jurisdictions that reduce sources of phosphorus from: urban sanitary systems, urban stormwater, residential unsewered systems, and other nonpoint sources in urban watersheds (eg: dust and streambank erosion). This review provides an analysis of the current regulatory or program gaps that exist in mitigating phosphorous loads to Lake Erie. No jurisdiction successfully mitigated all sources of phosphorous. This was driven by shortcomings in monitoring efforts and funding availability. The project produced a series of recommendations and forward looking tools that may be required for future management and maintenance of a healthy Lake Erie - they can be applied to improve water quality in other Great Lakes jurisdictions. *Keywords: Phosphorus, Best Management Practices, Lake Erie, Environmental Management, Urban areas, Nearshore.*

NEUREUTHER, N.J.[1], JOHNSON, W.E.[2], KIMBROUGH, K.L.[2], JACOB, A.[2], and KLAPER, R.D.[1], [1]School of Freshwater Sciences, University of Wisconsin-Milwaukee, 600 East Greenfield Ave, Milwaukee, WI, 53217; [2]NOAA's Mussel Watch Program, 1305 East West Highway, SSMC4, Room 9202, Silver Spring, MD, 20910. **Determining the impacts of toxics in the Great Lakes using genomic biomarkers of mussels involved in the contaminant monitoring of the NOAA Mussel Watch Program.**

There have been several remediation efforts for toxics in the Great Lakes Areas of Concern (AOC). However, in addition to chemical remediation, there is a need to gauge whether remediation efforts have also improved the health of organisms living in these ecosystems. It is our assertion that genomic indicators maybe able to provide data that managers can use to assess the removal of BUI's and delist AOC's more efficiently. In this project we examined genomic biomarkers related to stress and pollutant exposure in dreissenid mussels in locations known to be heavily contaminated, sites that had been remediated, and sites that are less contaminated as determined by chemical analysis. Our research occurred in conjunction with NOAA's NCCOS Mussel Watch Program, which monitors chemical pollution in the Great Lakes using these same mussels. Using the Manistique, Michigan AOC as a test site, qPCR was used to measure candidate biomarkers to identify the sources and potential impacts of PCBs contributing to high concentrations in localized areas of the AOC. Our data indicate a distinct gradient for mussels from "clean" versus contaminated sites where PCB's in particular cause significant changes in selenium-dependent glutathione peroxidase. This work is currently being expanded to other sites with different contamination profiles. *Keywords: Environmental effects, Biomonitoring, Environmental contaminants.*

NEVERS, M.B.[1], BYAPPANAHALLI, M.N.[1], PHANIKUMAR, M.S.[2], KELLY, K.[1], and WHITMAN, R.L.[1], [1]U.S. Geological Survey, Great Lakes Science Center, 1100 N. Mineral Springs Road, Porter, IN, 46304; [2]Michigan State University, Department of Civil and Environmental Engineering, A130 Engineering Research Complex, East Lansing, MI, 48824. **Integration of Nearshore Beach Modeling Efforts to Assess Indicator Bacteria Contamination Sources and Transport Mechanisms.**

Mathematical models are used for predicting and forecasting water conditions, hygienic quality, and for tracking sources of microbial contamination. Data on source, fate, and transport of microbial contaminants have been generated through predictive and hydrometeorological modeling efforts around the Great Lakes. Applied models have been used by beach managers in Chicago, Indiana, and others to predict ambient water quality in real time to protect humans from waterborne illnesses. Patterns of contamination at Lake Michigan beaches and influences on large and small-scale fluctuations in indicator bacteria (i.e., *E. coli*) concentrations were described using data from a range of disciplines: monitoring, DNA fingerprinting, and hydrometeorology. In Chicago, beach-specific influences are identified, including embayment and resuspension, but underlying these are regional processes (wave conditions and barometric pressure) sufficient to describe up to 40% of the variation in *E. coli* concentrations. Results from DNA fingerprinting for *E. coli* show significant heterogeneity among beaches, indicating the lack of a single driving source. Collectively, these studies provide insight for contamination remediation and implementing restoration opportunities at urban, suburban, and natural area beaches. *Keywords: Water quality, Model studies, Microbiological studies.*

NGHIEM, S.V.[1] and LESHKEVICH, G.[2], [1]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, MS 300-235, Pasadena, CA, 91109; [2]3NOAA/Great

Lakes Environmental Research Laboratory, 4840 South State Road, Ann Arbor, MI, 48108.
**Soil Moisture Change and Impacts in the Great Lakes Basin.**

Soil moisture change and impacts in the Great Lakes Basin are examined with satellite observations. Backscatter data acquired by satellite Ku-band scatterometers such as QuikSCAT (QS) and Oceansat-2 (OS) can be used to monitor soil moisture over the extensive scale of the Great Lakes Basin. Many physical models have been developed to characterize backscatter signatures of vegetated soil. In practice, empirical model functions (EMF) are used to obtain soil moisture estimates. We use a soil moisture EMF derived for applications with a Ku-band backscatter to map soil moisture change (SMC) on the land surface. SMC represents the amount of wetness in soil from precipitation water that actually reaches and accumulates in soil, as opposed to rainwater that evaporates in the air such as in virga (dry thunderstorm). As such, soil moisture change can truly represent hydrological impacts on the land surface and affects stream flow and river discharge into the Great Lakes. We present several examples to contrast the differences in water extremes in storm and drought cases. Particularly in the Great Lakes region, urbanization can impact water resources and quality, while water extremes can inflict severe disasters in extensive urban areas. *Keywords: Remote sensing, Soil moisture, Satellite technology, Hydrologic budget.*

NIBLOCK, H., MUNAWAR, M., and FITZPATRICK, M., Fisheries & Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **Ecology and Dynamics of Planktonic Communities in Western Lake Ontario: 2013 Intensive Studies.**

Traditionally lake wide research and monitoring cruises in the Great Lakes have been carried out every 5 years on a rotational basis including Lake Ontario. These lake wide surveys provide extremely important spatial and ecological information about the health of the lake however this approach lacks intensive seasonal data necessary for making holistic assessments. Consequently, an intensive biweekly sampling program was implemented at one near shore (7m) and one offshore (60m) station in the western end of Lake Ontario from May to November. Sampling included profiles of temperature, light, oxygen, conductivity, pH and chlorophyll a. Integrated water was collected for nutrients, phytoplankton biomass-composition, primary productivity and bacterial growth. Both stations were oligotrophic with an average chlorophyll a concentration of 3.1 µg/l (near shore) and 2.4 µg/l (off shore). Chlorophyll a profiles exhibited deep chlorophyll maxima formation during the spring and summer seasons. Primary productivity was generally low, on average 5 - 6 mg C/m3/h at both locations. This presentation will highlight the results of the intensive study in compari-

son with previous lake wide cruises in order to offer some new insights on plankton dynamics in Lake Ontario. *Keywords: Monitoring, Primary production, Algae, Nutrients.*

NIEDERKORN, A., REZANEZHAD, F., and VAN CAPPELLEN, P., Ecohydrology Research Group, University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L 3G1. **Stream-riparian-hyporheic connections.**

Biogeochemical and hydrological processes in riparian and hyporheic zones have the potential to significantly influence the fate and transport of nutrients at the river catchment scale. To better understand the effects of near-stream zones on stream biogeochemistry, we conducted a field experiment on a small groundwater-fed tributary stream of the Grand River located in the rare Charitable Research Reserve, Cambridge, Ontario, Canada. In particular, we focused on the spatial and temporal distributions of water quality parameters within the riparian and hyporheic zones of the stream. Several piezometer nests were installed near the stream and sampled bi-weekly from May to November 2013. In addition, a series of passive (diffusion) water samplers, known as peepers, were installed along longitudinal and lateral transects centered on the stream. In this presentation, we discuss the measured distributions of groundwater and surface water nutrients (C, N, P, S and Si). The results show that biogeochemical processes and water quality vary significantly on spatial scales of meters or less. *Keywords: Water quality, Biogeochemistry, Nutrients.*

NIEMI, G.J.[1], HOWE, R.W.[2], BRACEY, A.M.[1], PANCI, H.[1], and TOZER, D.C.[3], [1]NRRI, University of Minnesota, 5013 Miller Trunk Highway, Duluth, MN, 55811; [2]University of WI-Green Bay, Dept. of Natural & Applied Sciences, Green Bay, WI, 54311; [3]Bird Studies Canada, P.O. Box 160, 115 Front St., Port Rowan, ON, N0E 1M0. **Predicting Occurrences of Indicator Bird Species in Great Lakes Coastal Wetlands.**

Quantitative models predicting species' occurrences help validate the use of these species as reliable ecological indicators and can be used to adjust indicator metrics according to biogeography and other local or regional factors. To effectively evaluate the condition of a wetland, predictions of indicator species such as secretive and rare wetland birds is essential. We are developing models to predict the habitat suitability of 16 wetland-obligate bird species throughout the Great Lakes coastal region. From 2002-2003 and 2011-2013 we systematically sampled breeding bird populations at 1006 survey points in coastal wetlands along the U.S. and Canadian shorelines. Models are being developed using U.S. and Ontario land-cover, climate, and hydrology data at 500, 1000, and 2000 m buffers of each point sampled.

Based on preliminary results, Sedge (*Cistothorus platensis*) and Marsh Wren (*C. palustris*), two species of conservation concern, were observed at 13% and 25% of 840 sites, respectively, but were predicted to have potentially suitable habitat at 47% and 56% of the sites sampled. There are at least three possible reasons for this discrepancy: 1) inefficient sampling, 2) lack of habitat saturation, or 3) inaccurate models. We will test the models and sampling efficiency using data from 2014-2015 *Keywords: Bioindicators, Avian ecology, Coastal wetlands.*

NISHIZAKI, M.T. and ACKERMAN, J.D., Department of Integrative Biology, University of Guelph, Guelph, ON, N1G 2W1. **Using Eddy Correlation to Assess Benthic Oxygen Flux During Late Fall and Winter.**

The flux of oxygen and other scalars to and from the aquatic sediments is important to many biogeochemical processes and water quality in general. Whereas there are a number of measurements of oxygen flux, using different techniques, during warm weather conditions, there are fewer in colder months when sediment oxygen demand combined with low primary productivity can lead to oxygen depletion and that in turn affects many aspects of lake ecology. We present preliminary oxygen and heat flux data collected using eddy correlation in Guelph Lake, an impoundment of the Grand River, ON, during late fall and winter including day versus night measurements that allow for estimates respiration and productivity. Using simultaneous measurements of oxygen, temperature, and three velocity components, we derived the vertical oxygen- and heat-flux using the eddy correlation technique. Results suggest the presence of generally low flux that may occur both to and from the benthos depending on light intensity. *Keywords: Oxygen, Eddy correlation, Benthos.*

NOODIN, M.A. and ZIMMERMAN, M.L., UW-Milwaukee, 2310 East Hartford Ave, Milwaukee, WI, 53211. **Connecting Anishinaabe Stories with Science.**

In contemporary society, all too often when Native perspectives are invoked it is with a propensity to concentrate on the more aesthetic, abstract qualities of their worldviews without much credence to their simultaneous basis in more concrete, scientific understandings. Part of the reason for this is due to the differences in structure and focus of the languages of articulation; between Anishinaabemowin and English for example. In Oceanography for further example, terms used for processes and marine organisms associated within are generally referred to in English in ways that emphasize noun-based understandings of the hydrosphere, whereas in Anishinaabemowin the descriptions of the same invoke verb-based understandings that reflect a more organic observation of the processes and organisms at

work. These understandings continue today through language use within story. Using grammar and composition examples from first and second year Anishinaabemowin courses and examples of description and research from Oceanography and Biology courses, we will demonstrate how introductory courses can convey greater reverence for the content by combining scientific, linguistic, and cultural perspectives. By offering a few concrete examples in the presentation we hope to encourage further conversations in interdisciplinary pedagogies. *Keywords: Aboriginal, Anishinaabe, Commons, Anishinaabemowin, Great Lakes basin.*

NORRIS, T. and CORCORAN, P.L., Department of Earth Sciences, University of Western Ontario, London, On, N6A 5B7. **Transport Pathways and Accumulation Rates of Plastic Debris near Humber Bay, Lake Ontario.**

Accumulation and persistence of plastic debris in waterways pose a serious threat to aquatic ecosystems. Many studies have investigated the accumulation and effects of plastic debris in marine environments, but few have examined the accumulation of plastics in fresh water environments. A section of beach along the shoreline of Humber Bay, Lake Ontario was surveyed for industrial plastic pellets, plastic fragments, and intact plastic debris. The accumulation rate of plastics was calculated by sampling from a quadrat measuring 25m x 4m over 3 week intervals. An average of 1500 pellets, 405 plastic fragments, and 91 intact plastic items accumulated per 3 week interval. A site along the Humber River, which drains into Humber Bay, was surveyed in order to assess the river's potential as a transport pathway for plastic pellets into Lake Ontario. The shoreline and riverbank sampling areas contained comparable pellet compositions and colours. Using Raman Spectroscopy on random pellets, polymer compositions included high density polyethylene, low density polyethylene and polypropylene, which are all considered floating plastic polymers. Understanding the relationship between sources, transport pathways and sinks for plastics will help locate key areas for investigations concerning the effects of plastic debris on aquatic organisms. *Keywords: Microplastics, Coastal processes, Lake Ontario.*

NOWELL, P.M.[1], EVANS, L.J.[1], ASPINALL, J.D.[2], and SWEENEY, S.J.[2], [1]University of Guelph, School of Environmental Sciences, Guelph, ON, N1G 2W1; [2]Ontario Ministry of Agriculture and Food and Ministry of Rural Affairs, Environmental Management Branch, Guelph, ON, N1G 4Y2. **Intrinsic Soil Phosphorus Retention/Release Characteristics in the Agricultural Landscape of the Rondeau Bay Watershed, Ontario: Preliminary Results.**

Non-point source phosphorus (P) loadings to the Great Lakes are a binational lake management concern. Agricultural cropping system management is a prominent component of nutrient load impact mitigation strategies. At present, essential information is lacking for managing Ontario's agricultural soil landscape P reservoir. Accurate soil map information, at scales appropriate for on-farm decision-making, is required. Detailed soil properties must be described, measured and mapped to better understand their spatial extents. The clay mineralogy of many Ontario soil series has never been described. This study has characterized the clay minerals of Rondeau Bay watershed soils for the first time. It then focused on the chemical interactions of P with them to determine the intrinsic P retention/release characteristics of these soils. A surface complexation model was developed to predict phosphate adsorption to two reactive surfaces - clay minerals and iron oxides. This model provides an estimate of plant available and adsorbed P in the soil environment. Predictive digital soil mapping (PDSM) approaches were applied to high-resolution LiDAR-based DEM's and strategic soil site investigation information across the study area. This permitted extrapolation of the intrinsic soil P retention/release sensitivity findings throughout this area. *Keywords: Phosphorus, Soil chemistry, Agricultural landscape, Retention/release.*

NURNBERG, G.K.[1] and SHEAD, J.[2], [1]Freshwater Research, 3421 Hwy. 117, Baysville, ON, P0B 1A1; [2]Manitoba Conservation and Water Stewardship, Suite 160, 123 Main Street, Winnipeg, MB, R3C 1A5. **Internal Phosphorus Load Assessment in Lake Winnipeg.**

Recent cyanobacterial blooms and other signs of eutrophication in Canada's 6th largest lake, Lake Winnipeg, Manitoba, have caused concern. While the lake's enormous watershed (40x lake area) is responsible for a large nutrient input there are indications of an internal phosphorus source as P release from bottom sediments even though the lake seldom stratifies. Such P is highly biologically available and could support cyanobacteria blooms. The southern basin is shallow and extensively mixed so that sediment is resuspended creating high turbidity; the deeper northern basin and the "Narrows" are more likely to respond to redox-dependent P release from sediment. There are several indications of internal P load in the northern basin, such as increased total P, iron and manganese concentrations and low dissolved oxygen concentrations (less than 2 mg/L) in deep waters at several stations. Using long-term data (1992-2012) collected by provincial and federal agencies and experimental results from previous studies, internal load is being quantified by several approaches (summer and fall TP increases; monthly mass balances; P release and hypoxia model) in Lake Winnipeg's three basins (North, South and Narrows). Preliminary results from all three approaches available for the northern basin indicate a substantial internal load. *Keywords: Lake Winnipeg, Internal P load, Eutrophication, Phosphorus.*

# O

O'DONNELL, D.M., EFFLER, S.W., STRAIT, C.M., PERKINS, M.G., and PENG, F., Upstate Freshwater Institute, PO Box 506, Syracuse, NY, 13214. **Remote sensing reflectance in the Great Lakes: In situ measurements, closure analyses, and a forward model.**

Observations of remote sensing reflectance (Rrs), the signal available to support remote sensing of optically active constituents (OACs) of water quality interest, are presented for multiple sites within each of the Laurentian Great Lakes based on in situ measurements made with a hyperspectral radiometer. Rrs spectra are contrasted among these lakes and in time and space within selected systems. Qualitative analyses of spectra are provided that identify the inherent optical property (IOP) and coupled OAC conditions responsible for the differences in Rrs. The much higher Rrs peaks observed in the green wavelengths for the lower Great Lakes(Erie and Ontario) are attributed to elevated backscattering levels caused by higher concentrations of minerogenic particles. The credibility of the Rrs spectra is established through successful closure analyses that demonstrate good matches with IOP-based predictions and consistency of coefficient values for radiative transfer expressions with related literature and theory. A mechanistic forward model of Rrs is developed that accommodates the effects of three OACs, including metrics of phytoplankton biomass, minerogenic particles and colored dissolved organic material. This includes the development of the critical cross-section relationships that quantify the couplings between the OACs *Keywords: Remote sensing, Optically active constituents, Underwater optics.*

O'MALLEY, B.P.[1], WATKINS, J.M.[1], RUDSTAM, L.G.[1], HOLDA, T.J.[1], and WEIDEL, B.C.[2], [1]Cornell Biological Field Station, 900 Shackleton Point Road, Bridgeport, NY, 13030; [2]USGS Lake Ontario Biological Station, Lake St. & W. 3rd St., Oswego, NY, 13126. **Lake-wide patterns in chlorophyll usage by *Mysis* in Lake Ontario: The gut fluorescence technique.**

Quantifying the role of phytoplankton in *Mysis* diets often necessitates lab-derived clearance rates rather than direct field-based estimates. Measuring phytoplankton fluorescence of gut contents is common in marine plankton research and may provide a method to quantify *in situ* grazing by omnivorous *Mysis diluviana* in the Great Lakes. Previous research suggests grazing is only an important part of *Mysis* diets in early spring, prior to thermal stratification. We hypothesize the presence of a deep chlorophyll layer could allow mysids to graze on diatoms and other phytoplankton even after the onset of thermal stratification. We tested our hypothesis using samples collected from Lake Ontario during May, July, and September of 2013. Preliminary results offer weak evidence for our hypothesis, showing that chlorophyll was most abundant in stomachs during May for both adults and juveniles, suggesting heavy grazing during spring, whereas in July and September mysids fed more on zooplankton. We also identified phytoplankton in stomach contents to genus when possible. Future studies could potentially use gut fluorescence in conjunction with stomach content analysis as methods to estimate grazing pressure of other invertebrates in the Great Lakes as well. *Keywords: Diatoms, Mysis diluviana, Lake Ontario.*

O'NEIL, J.A.[1], DROUILLARD, K.G.[1], and JOHNSON, T.B.[2], [1]Great Lakes Institute for Environmental Research, University of Windsor, Windsor, ON, N9B3P4; [2]Glenora Research Station, Ontario Ministry of Natural Resources, Picton, ON. **Comparing standard metabolic rate of round goby (Neogobius melanstomus) and tubenose goby (Proterorhinus semilunaris) over a temperature gradient.**

Standard metabolic rates of round goby and tubenose goby were determined by intermittent flow respirormetry over temperatures of 10, 18, 23, 26 and 30oC. Oxygen consumption was measured in fish from each species and temperature over 24 h. Both species exhibited periods of heightened oxygen consumption, interpreted to reflect a stress response of fish within chambers and periods where oxygen consumption minima occurred. As such, two metrics were derived for each fish over the 24 h measurement periods. SMRtotal provided a measure of average metabolic rate of fish (excluding the initial 4 h) over the 24 h measurement while SMRmin provided a baseline metabolic rate estimate. For round and tubenose gobies, SMRtot averaged 57% and 69% higher than SMRmin, respectively. Following allometric adjustment for size differences between individuals, there were no significant differences in SMRmin between species across temperatures. However, SMRmin of round gobies increased with temperature, whereas tubenose gobies exhibited a peak in SMRmin at 23oC. Differences by species was observed for SMRtot, with higher metabolic rates observed for tubenose goby at the 26 and 30oC temperatures. These observations suggest round gobies have lower stress response and higher tolerance relative to tubenose goby for high temperature conditions. *Keywords: Bioenergetics, Invasive species, Metabolism.*

OBENOUR, D.R.[1], GRONEWOLD, A.D.[2], and SCAVIA, D.[3], [1]University of Michigan Water Center, 214 S. State St., Suite 200, Ann Arbor, MI, 48104; [2]NOAA GLERL, 4840 S. State Rd., Ann Arbor, MI, 48108; [3]Graham Sustainability Institute, 625 E. Liberty St., Suite 300, Ann Arbor, MI, 48104. **A Decision Support Model for Cyanobacteria Blooms in the Western Basin of Lake Erie.**

The last decade has seen a dramatic increase in the size of Lake Erie cyanobacteria blooms, renewing concerns about nutrient loading, the primary anthropogenic driver of these blooms. However, it is unclear how much of the year-to-year variability in bloom size is explained by anthropogenic nutrient loading, and how much natural variability will remain if nutrient loading is reduced. This study addresses these questions by developing a probabilistic model to predict the late-summer bloom size in terms of the spring phosphorus load. Because of the need to accurately represent predictive uncertainty, different statistical formulations are critically evaluated through cross validation, and a gamma error distribution is found to provide the most realistic uncertainty characterization. We also demonstrate how a hierarchical modeling framework with 'yearly random effects' allows for the model to be simultaneously calibrated to multiple sets of bloom observations. In addition we compare total phosphorus and soluble reactive phosphorus based on their predictive capabilities. Finally, we demonstrate how the model can be used to make annual forecasts, aid in setting management goals, and study long-term changes in the Lake's propensity to generate large cyanobacteria blooms. *Keywords: Model studies, Lake Erie, Algae.*

OLSON, D.S.[1] and DILLON, R.A.[2], [1]University of Wisconsin-Milwaukee School of Freshwater Sciences, 600 E Greenfield Ave, Milwaukee, WI, 53204; [2]University of Vermont, Burlington, VT, 05401. **The Diets of Hatchling Round Gobies in Western Lake Michigan.**

First feeding can be a critical stage in fish recruitment and the prey types are indicative of important habitat. Hatchling round gobies were collected in summer 2013 from six sites along Lake Michigan's western coastline from Manitowoc to Milwaukee, WI. Three environment types were sampled including nearshore lake sites (approx. 5 m), Lake Michigan tributaries characterized by gentle flow, and shallow harbor sites (1 m or less). 123 hatchlings were collected in total with at least 19 at every site. Individual fish measured between 9-23 mm of total length. Collection methods included hand netting by SCUBA divers, seine netting, and suction sampling using ROV's. On average, harpacticoid copepods were the most abundant prey item for lentic fish, composing between 56.9% and 82.5% of consumed invertebrates. Cyclopoid copepods were abundant in the diet of hatchlings collected at the Port Washington Marina and Silver Creek sites only; composing 12% and 37.9% of diet

items, respectively. Chironomid larvae were an important food source for hatchlings at all sites, appearing in the stomachs of 71.5% of fish. Size of individual fish did not correlate with a shift in diet at any site. This study sheds light on the important role of meiofauna in Lake Michigan's post-dreissenid, nearshore dominated food web. *Keywords: Lake Michigan, Meiofauna, Round goby, Diets.*

ONI, S.K.[1], FUTTER, M.N.[1], LEWIS, L.A.[2], DILLON, P.J.[3], and CROSSMAN, J.H.[4], [1]Dept. Aquatic Science and Assessments, Swedish University of Agricultural Science, Uppsala, SW, 75007, Sweden; [2]Faculty of Environmental Studies, York University, Toronto, ON, M3J 1P3; [3]Environemtal and Resource Studies, Trent University, Peterborough, ON, K9J 7B8; [4]Department of Chemistry, Trent University, Peterborough, ON, K9J 7B8. **Uncertainty Assessments and Hydrological Implications of Climate Change in Two Adjacent Agricultural Catchments of Lake Simcoe Watershed.**

Lake Simcoe is an important inland lake in Southern Ontario. The watershed is predominantly agricultural and under increasing pressure from urbanization, leading to changing runoff patterns in rivers draining to the lake. Uncertainties in rainfall-runoff modeling in tributary catchments of the Lake Simcoe Watershed (LSW) can be an order of magnitude larger than pristine watersheds, hampering water quality predictions and export calculations. Here we conduct a robust assessment to constrain the uncertainty in hydrological simulations and projections in the LSW using two representative adjacent agricultural catchments. Downscaled CGCM-3 projections using A1B and A2 emission scenarios projected increases of 4oC in winter air temperature and a 26% longer growing season. The fraction of precipitation falling as snow will decrease. Spring runoff is an important event in LSW but individual HBV best calibrated parameter sets under-predicted peak flows by up to 32%. Using an ensemble of behavioral parameter sets achieved credible representations of present day hydrology and constrained uncertainties in future projections. Parameter uncertainty analysis showed that the catchments differ in terms of their snow accumulation/melt and groundwater dynamics. Parameterization in one catchment could not generate credible simulations in others. *Keywords: Assessments, Uncertainty analysis, Climate change, Urbanization.*

OPOLKO, G.[1], ENGLISH, M.C.[1], and MACRAE, M.L.[2], [1]Wilfrid Laurier University, 75 University Avenue West, Waterloo, ON, N2L 3C5; [2]University of Waterloo, 200 University Ave West, Waterloo, ON, N2L 3G1. **Event Loads and Seasonal Trends of Suspended**

**Sediment and Phosphorus in Subsurface Runoff From Tile-Drained Fields Under Different Tillage Systems in Southwestern Ontario.**

Nutrient loading from non-point sources has been identified as a potential cause of accelerated eutrophication in the western basin of Lake Erie. Conservation tillage methods, once identified as solutions to nutrient loading, are now being identified as potential causes for the increase in concentrations of bioavailable phosphorus (P) to the tributaries of Lake Erie. In this study, three plots in a tile-drained field in St. Marys, Ontario were subjected to different tillage treatments including: conventional till (CT), rotational till (RT) and no-till (NT). Tile drains beneath the plots were instrumented with subsurface weirs and automatic water samplers that collected tile-flow at discrete time intervals during storm events for 16 months. Water samples were analyzed for suspended sediment concentration (SSC), total P (TP), and total dissolved P (TDP). Sample SSCs were substantially higher from CT plots compared to RT and NT plots. Similarly, flow-weighted mean concentrations, median concentrations, and total mass export for TP were higher in CT samples compared to RT and NT samples for the study period and greatest during the winter months. TDP values showed similar trends. These results have important implications for the implementation of beneficial management practices for the Lake Erie watershed. *Keywords: Sediment load, Agricultural Best Management Practices, Lake Erie, Tillage Method, Phosphorus.*

ORR, E.[1], ANTUNES, P.M.C.[2], WATSON, S.B.[3], PALUMBO, L.[1], GRAHAM, C.J.[1], THOMAS, V.J.[1], and NORMANDEAU, J.R.[1], [1]Central Algoma Freshwater Coalition, PO Box 159, Desbarats, ON, P0R 1E0; [2]Aquatox, 11B Nicholas Beaver Rd, RR3, Guelph, ON, N1H 6H9; [3]Environment Canada National Water Research Institute, 867 Lakeshore Road, P.O. Box 5050, Burlington, ON, L7R 4A6. **Examining Potential Causes of Poor Water Quality in Central Algoma Watersheds: Exploratory Investigative Actions on Desbarats Lake.**

Occurrences of severe outbreaks of Harmful Algal Blooms dominated by cyanobacteria (cHABs) in Canadian Shield Lakes have increased in recent years. Since 2004, there have been recurring cHABs in Desbarats Lake every 2-5 years and in 2009, the average total phosphorus level in surface water samples exceeded 35ug/L. The Central Algoma Freshwater Coalition (CAFC) was formed in 2009, to respond to cHABs in Desbarats as well as other lakes within watersheds of the Central Algoma Region. To investigate the possible cause(s) of high nutrient levels, CAFC carried out an extensive research program aimed at collecting both qualitative and quantitative data for a risk-assessment and remediation process. The data was collected in a three-tiered approach that included: gathering lake characteristics and lake history information for Desbarats Lake, a three-year water sampling program, and an inventory of shoreline vegetation and the shoreline's nutrient buffering capacities. Data acquired from this program (combined with data from the Ministry of Natural Resources Lake Partners Program), have provided important insights into the possible causes of the deteriorating water quality, and are being used as the basis for formulating a Watershed Management Plan for Desbarats Lake. *Keywords: Citizen science, Phosphorus, Lake Huron, Nutrients, Algae, Watershed management planning.*

ORTIZ ALMIRALL, X.[1], BACKUS, S.M.[1], MCGOLDRICK, D.J.[1], and REINER, E.J.[2], [1]Environment Canada - Canada Centre for Inland Waters, 867 Lakeshore Road, Burlington, ON, L7R 4A6; [2]Ministry of the Environment of Ontario, 125 Resources Road, Toronto, ON, M9P 3V6. **Occurrence of Substituted Diphenylamines in the Great Lakes.**

Diphenylamine reaction products with styrene and 2,4,4-trimethylpentene, 2-propanone or phenyl and tolyl derivatives are complex mixtures of variable composition widely used as antioxidants in vehicle engine oil and rubber products such as car tires. Based on their physical and chemical properties, these substituted diphenylamines are expected to be persistent in the environment. In addition, modelled acute aquatic toxicity data indicate that they are potentially highly hazardous to aquatic organisms. In order to assess the bioaccumulation of these compounds in biota, in the present study an analytical method for the analysis of substituted diphenylamines in fish has been developed based on the QuEChERS approach (Quick, Easy, Cheap, Effective, Rugged and Safe) and gas chromatography-tandem mass spectrometry instrumental determination. The validated method allows the analysis of a large number of fish samples (around 15-20) in one day using small amounts of organic solvents, thus making the method a more economically and environmentally friendly process. Preliminary data has shown the occurrence of a 2,4,4-trimetylpentene-styrene diphenylamine isomer in fish. *Keywords: Fish, Environmental contaminants, Bioaccumulation.*

OVEISY, A.[1], DIBIKE, Y.[2], PROWS, T.[3], and BELTAOS, S.[4], [1]W-CIRC,University of Victoria, Victoria, BC; [2]W-CIRC,University of Victoria, Victoria, BC; [3]W-CIRC,University of Victoria, Victoria, BC; [4]EC-NWRI, Burlington, ON. **A Lagrangian approach to ice dynamics in surface waters.**

Cold region surface water experience periods of ice cover and subsequent break up. During break up period the transport of ice parcels are very dynamic. The movement of ice parcels changes the hydraulics and transport regime of the rivers and ice coverage on the lakes. Therefore, modelling the ice transport accurately is important in correct simulation of hydrodynamics and sediment transport. Traditional Eulerian approach results in high diffusivity and dispersion particularly in rivers where the ice transport is very dynamic. Here we developed an ice dynamic model based on a discrete parcel method using a Lagrangian approach. The EFDC (Environmental Fluid Dynamic Code) numerical model has adapted and coupled with the ice dynamic model to form coupled ice and hydrodynamic model. The ice rheology is considered visco-plastic. The model was verified against theory and validated against observation. *Keywords: Ice dynamics, Lagrangian method, Ice jam and breakup.*

# P

PALMER, C.J.[1], STAPANIAN, M.A.[2], LEWIS, T.E.[3], AMOS, M.A.[1], and BLUME, L.J.[4], [1]CSC, 6361 Walker Lane, Suite 300, Alexandria, VA, 22310; [2]U.S. Geological Survey, 6100 Columbus Ave., Sandusky, OH, 44870; [3]U.S. Army Corps of Engineers, 3909 Halls Ferry Rd., Vicksburg, MS, 39180; [4]USEPA GLNPO, 77 West Jackson Blvd, Chicago, IL, 60604.
**Monitoring the Success of Ecological Restoration Efforts - Suggestions for Obtaining Reliable Ecological Measurements.**

An evaluation of the effectiveness of restoration efforts is an important component of adaptive management. Monitoring efforts often rely on field crew observations such as species presence, abundance or cover, condition, age classes, or gender. Although challenging, many steps can be taken to improve the quality and reliability of these measurements. An important first step is to establish quality objectives or tolerances for these measurements. These objectives are achieved through the use of standard operating procedures, careful crew training and certification, and field checks. Data review efforts ensure that data are complete, accurate, and are defensible from a scientific perspective. Repeated observations during routine field data collection or on reference plots can be used to estimate measurement error. The goal is to ensure that measurement uncertainty is not limiting the ability of restoration specialists to determine success in attainment of anticipated improvements in ecological condition. This presentation will indicate procedures and provide examples of how to apply quality assurance/quality control (QA/QC) practices to improve ecological measurements. *Keywords: Monitoring, Quality assurance, Indicators.*

PANKHURST, H.M., Central Lake Ontario Conservation Authority, 100 Whiting Avenue, Oshawa, ON, L1H 3T3. **The Durham Region Coastal Wetland Monitoring Project: Monitoring to Management - Making the Connection.**

The Durham Region Coastal Wetland Monitoring Project was initiated in 2002 and since that time physical and biological conditions have been monitored at 18 coastal wetlands. Indices have been developed to assess these conditions, and trend analysis has been completed to evaluate changes over time. The next step is to use this information along with wetland attributes and threat analyses to identify future management and restoration opportunities for each coastal wetland. The framework for a report which achieves this task is now in place and individual modules for each wetland are being completed. This presentation will discuss the components of this report as well as provide an example of a completed module for Cranberry Marsh where restoration action has been successful and ongoing management is supported by monitoring research. The completion of these modules is a necessary step to be able to evaluate the condition of coastal wetlands, observe changes in health over time, and to use this information effectively to provide recommendations for management and restoration. Consistently making the connection between monitoring results and management recommendations is essential to ensure that when changes are observed or threats identified adaptive management can be used to achieve a higher probability of success. *Keywords: Management, Monitoring, Wetlands.*

PARSONS, C.T. and VAN CAPPELLEN, P., 200 University Avenue West, Waterloo, ON, N2L 5G6. **Sediment Nutrient Dynamics Under Redox Oscillating Conditions (Cootes Paradise, Ontario).**

Cootes Paradise is a severely degraded river mouth wetland at the western tip of Lake Ontario. Severe algal blooms in the open water areas of the wetland have been previously ascribed to high internal phosphorus (P) loadings. To unravel the biogeochemical processes that contribute to benthic P release, sediment suspensions were subjected to alternating oxic and anoxic conditions in a bioreactor system, simulating oscillating conditions experienced at the sediment/water interface. At the start of each anoxic period, freeze-dried, native green filamentous algal matter was added to the reactor to avoid depletion of organic matter and stimulate activity within the native microbial community. Aqueous chemistry, mineralogy and organic geochemistry were monitored as a function of time, with a focus on the following elements: P, Fe, Mn, S, N and Si. During the redox cycles, the total dissolved P concentration fluctuated between 2.5 and 65 μM and was dominated by the soluble reactive phosphorus (SRP) fraction. The variations in total dissolved P concentration were strongly correlated with those of total dissolved Fe, Mn and Si. Sequential extractions and hydrolytic enzyme activity assays (phosphatases) were used to determine changes in solid-bound P and assess the potential mineralization of P associated with the algal matter additions *Keywords: Eutrophication, Iron, Wetlands, Redox, Phosphorus, Nutrients.*

PATERSON, G.[1], DROUILLARD, K.G.[2], and HAFFNER, G.D.[2], [1]SUNY-ESF, Forestry Drive, Syracuse, NY, 13210; [2]Great Lakes Institute for Environmental Research, 401 Sunset Avenue, Windsor, ON, N9B 3P4. **Investigating Temporal Responses of Lake Huron Lake Trout Energy Densities During Ecosystem Change.**

Energy density data represent an important component for bioenergetics modeling efforts and the capacity to predict species' responses to multiple stressors such as invasive species, nutrient remediation programs and ecosystem change. In this study, we used long term biomonitoring data to calculate energy densities for multiple age classes of lake trout collected from throughout Lake Huron from 1977 - 2011. The resulting estimates demonstrated a similar bi-linear relationship with body mass as previously determined for this species using traditional calorimetry methods and were also in high agreement with previously developed regression models for predicting lake trout energy densities. More recently, these data indicate substantial changes in the extent of energy assimilation by this top predator during the timeframe that is consistent with the introduction and establishment of dreissenid mussels in the Lake Huron ecosystem. These data demonstrate a value added component of long term environmental contaminant biomonitoring programs for investigating changes in food web structure and functioning that may affect energy flow and availability. Specifically, this approach may prove beneficial for investigating the potential cascading effects of dreissenid induced ecosystem change on top predators in Great Lakes food webs. *Keywords: Lake Huron, Lake trout, Bioenergetics.*

PATERSON, G.[1], DROUILLARD, K.G.[2], and HAFFNER, G.D.[2], [1]SUNY-ESF, 1 Forestry Drive, Syracuse, NY, 13210; [2]Great Lakes Institute for Environmental Research, 401 Sunset Avenue, Windsor, ON, N9B 3P4. **Individual Efficiencies and Lake Trout Responses to Fluctuating Prey Fish Biomass.**

Understanding top predator responses to changing ecological conditions such as fluctuating food abundances remains a primary concern of ecologists and natural resource managers. Here, we present a method for evaluating and comparing the efficiencies with which lake trout assimilate food energy from their natural habitat and explore relationships with primary metrics including spatial and temporal changes in prey fish abundances. Using field data from lake trout collected from Lake Huron's North Channel, Georgian Bay and Main Basins in 2011 and 2012, we demonstrate differences in energy assimilation which are highly correlated with basin specific prey fish densities. Bioenergetics model predictions indicate that this relationship is consistent with the manner in which lake trout are predicted to search and track prey resources in their native habitat and under varying prey abundances. We also apply this technique to long-term biomonitoring data for Lake Ontario lake trout in order to evaluate its applicability and also the potential responses of this population to temporal fluctuations in prey fish biomass. This method could provide novel information toward understanding individual and population efficiencies and also food web ecological efficiencies and phenomena such as food web bioaccumulation and biomagnification *Keywords: Lake trout, Bioenergetics, Lake Huron.*

PENNUTO, C.M.[1], KUDNEY, K.[2], JANIK, C.[2], and FISCHER, A.[2], [1]Great Lakes Center, Buffalo State College, Buffalo, NY, 14222; [2]Biology Department, Buffalo State College, Buffalo, NY, 14222. **Macroinvertebrate Communities and Leaf Litter Processing Are Changed by the Presence of Round Gobies in Lake Erie Tributary Streams.**

Organic matter processing provides significant nutrient and energy resources to macroinvertebrate communities in streams through a series of coupled resource-consumer links. Insertion of a new, generalist predatory invertivore into native communities has the potential to disrupt these coupled resource-consumer links. We assessed whether macroinvertebrate communities in tributary streams to Lake Erie changed when round gobies were present or absent and whether those changes led to any alterations in OM processing. Round gobies now occur in a large number of tributary waters to the Great Lakes. The relative proportions of different functional feeding groups, community composition, taxa richness, and community diversity of macroinvertebrates all were altered in streams harboring round gobies. Leaf litter breakdown rates were significantly slower at sites with round gobies present, both in summer and in fall. However, no change in bacterial communities within leaf packs was observed. These observations indicate that this benthic consumer can have a strong community organization impacts in small streams of the Great Lakes basin. How changes in organic matter processing ultimately affect stream ecosystem dynamics requires further investigations. *Keywords: Invasive species, Macroinvertebrates, Round goby.*

PEREZ-FUENTETAJA, A.[1], CLAPSADL, M.D.[1], PENNUTO, C.M.[1], and MAYER, C.M.[2], [1]Great Lakes Center, SUNY - Buffalo State, Buffalo, NY, 14222; [2]University of Toledo, Department of Environmental Sciences and Lake Erie Center, Toledo, OH. **Inter-Annual Dynamics of Zooplankton and Nutrient Regimes in Lake Erie.**

Zooplankton and nutrient dynamics in the three basins of Lake Erie were studied in the summers of 2011 and 2012. Those two years were characterized by different precipitation regimes which affected nutrient distribution in the lake and the severity of noxious algal blooms. Zooplankton also reflected those inter-annual differences in their biomass and distribution. However, the three basins of the lake responded in different ways to the limnological changes between years driven by the precipitation and temperature regimes. This study explores the differences and the resulting secondary productivity variation among basins in both years. *Keywords: Nutrients, Zooplankton, Lake Erie.*

PERHAR, G. and ARHONDITSIS, G.B., University of Toronto, Ecological Modelling Laboratory, Toronto, ON, M1C 1A4. **Using A Metabolite-Driven Daphnia Physiology Model as an Early Warning System for Ecosystem Health.**

Daphnia is a keystone filter feeder that has a strong impact on phytoplankton community biomass and species composition. It is also a preferred food item for both vertebrate and invertebrate predators, stemming largely from its nutritious composition, large size, and inability to evade predation. Metabolomics is a new methodology that provides an integrated view of biochemistry in complex organisms and allows the functions of both cells and whole organisms to be explored at the molecular level. We present a mechanistic metabolite-driven model of an individual daphnid. Metabolites are linked to physiological processes, and metabolite somatic concentrations are used to quantify various aspects of organism health. We highlight the model's ability to capture life history strategies against a variety of environmental conditions, and introduce a management-friendly Daphnia health metric. Our overarching goal is to create an early warning system, through which Daphnia metabolomic profiles are extrapolated to water body health metrics. The proposed framework addresses the critical need to develop rapid, reliable indicators for monitoring the quality of aquatic ecosystems at the molecular-level and examine how these indicators can be used to predict potential ecological shifts via aquatic ecosystem models. *Keywords: Ecosystem modeling, Zooplankton, Environmental health, Eutrophication, Indicators, Early warning systems.*

PERRI, K.A. and BOYER, G.L., SUNY-ESF, 1 Forestry Drive, Syracuse, NY, 13210. **Examination of Cyanobacterial Siderophore Production in Culture and Lake Erie.**

Iron is required for all living organisms. Under oxic conditions, iron is not readily available for biological uptake. To meet their needs, some microorganisms produce chelators called siderophores that can facilitate the uptake of iron from the surrounding environment. The iron uptake mechanism(s) for *Microcystis*, a common freshwater cyanobacterium, are not well established. To test if siderophores are an important iron uptake mechanism in this genus, three cyanobacteria species were grown in iron-limited media. This includes the known siderophore producer *Anabaena* sp. ATCC 27898, the type strain *Microcystis aeruginosa* NIES 843, and the Lake Erie isolate *M. aeruginosa* LE-3. Preliminary data from culture and field experiments will be presented. *Keywords: Cyanophyta, Iron, Lake Erie.*

PETCHPRAYOON, P.[1], BLANKEN, P.D.[1], LENTERS, J.D.[2], SPENCE, C.[3], and GRONEWOLD, A.D.[4], [1]University of Colorado, Department of Geography, Boulder, CO, 80309-0260; [2]LimnoTech, Ann Arbor, MI, 48108; [3]Environment Canada, Saskatoon, SK, S7N 5C8; [4]NOAA - GRERL, Ann Arbor, MI, 48108-9719. **A Decade of Warming on the Great Lakes from MODIS Surface Temperature Observations.**

This study examines the spatiotemporal distribution of surface water temperature over the Great Lakes using remotely sensed data. Eleven years of 1 km x 1 km surface temperature data between 2002-2012 were analyzed using images from the Moderate Resolution Imaging Spectroradiometer (MODIS) on board NASA's Terra satellite. Comparison of MODIS-derived surface temperature to in-situ point observations from Lake Huron yields satellite minus in-situ differences of 0.57 K for clear-sky conditions, and -0.30 K for cloudy-sky conditions. Despite the short 11-year record, summer-mean water surface temperatures (JJA) show statistically significant trends for each of the Great Lakes. Lake Superior has the highest warming rate, followed by Michigan, Huron, Ontario, and Erie. Except for Lake Erie, the warming rate is found to be greatest in the deepest areas of each lake, showing a statistically significant correlation between warming rate and depth. Here, we discuss these relationships and present possible explanations for why the deeper portions of the lake warm the fastest. *Keywords: Atmosphere-lake interaction, Remote sensing, Climate change.*

PETTITT-WADE, H., WELLBAND, K.W., HEATH, D.D., and FISK, A.T., Great Lakes Institute for Environmental Research, University of Windsor, 401 Sunset Avenue, Windsor, ON, N9B3P4. **Isotopic Niches and Potential for Dietary Plasticity in Round Goby and Tubenose Goby in The Great Lakes.**

Niche width analysis is a useful approach for determining the potential ecological impact of an invasive species. Comparing the niche of successful and less successful invasive species can elicit traits of most concern. We compared the isotopic niche of round goby (*Neogobius melanostomus*) to the isotopic niche of the less geographically widespread tubenose goby (*Proterorhinus semilunaris*) in the Great Lakes Basin. Bayesian ellipses of $\delta^{13}C$ and $\delta^{15}N$ (IRMS) were used to depict dietary and spatial niche space for each population. Multiple tissues were compared to provide an indication of potential niche plasticity. The data suggests the two Gobiids shared minimal resource competition, and that round goby feeds at a higher trophic level. In Lake St Clair tubenose goby had a broader isotopic niche than similar size round goby, whereas scope for plasticity in round goby is suggested to occur in larger individuals. Comparison of round goby in Lake St Clair to other Great Lakes locations highlights the importance of time since establishment on niche breadth, niche plasticity and potential overlap with other species. *Keywords: Stable isotopes, Goby, Great Lakes basin, Niches.*

PINHEIRO, V.M., STOCKWELL, J.D., and MARSDEN, J.E., University of Vermont, Burlington, VT, 05405. **Champlain Acoustic Telemetry Observation System (CATOS): Investigating Lake Trout Spawning Behavior and the Impact of Habitat Fragmentation on Lake Whitefish.**

CATOS is a new acoustic telemetry array, modeled after a similar system in the Great Lakes (GLATOS), that provides infrastructure for collaborative fish behavior studies incorporating projects among multiple institutions. At present, CATOS consists of 12 acoustic receivers in an array maintained by the Rubenstein Ecosystem Science Laboratory at UVM, with plans to expand to 28 receivers in 2014. Two current projects focus on lake trout behavior and impacts of habitat fragmentation. We have tagged 40 lake trout to study their movements and spawning site fidelity. We hypothesized that males remain at individual sites whereas females 'sample' multiple spawning reefs and populations of males to maximize their reproductive success; limited data to date suggest both sexes range widely during the spawning season. The second project will examine the effect of habitat fragmentation resulting from historic construction of several causeways on Lake Champlain. Whitefish are abundant in the main lake and scarce in regions that were historically commercial seining grounds but are now isolated by the causeways. We expect whitefish movements through the few narrow and shallow causeway openings will be limited by lake stratification. Discussions with partner institutions on future projects include movement studies on walleye and salmon. *Keywords: Fish behavior, Acoustic telemetry, Habitat fragmentation.*

PISKUR, M.S., Council of Great Lakes Governors, 20 N Wacker Dr, Suite 2700, Chicago, IL, 60606. **A Cumulative Impact Assessment of Water Uses in the Great Lakes-St. Lawrence River Basin.**

Water resource managers need accurate water data and information for decision making. Assessing and managing the cumulative impacts of multiple water uses over time and as part of a comprehensive water budget presents a particular set of challenges. While work of this nature has been done on smaller scales, no comprehensive cumulative impact assessment had ever been conducted on a scale similar to the Great Lakes-St. Lawrence River Basin. In 2012 and 2013, the Great Lakes Governors and Premiers conducted the first ever assessment of cumulative water use impacts for the Basin. This groundbreaking effort, completed in December 2013, was undertaken pursuant to the Great Lakes-St. Lawrence River Basin Sustainable Water Resources Agreement and the companion "Great Lakes Compact." The assessment focused on the cumulative impacts of consumptive uses, withdrawals, and diversions relative to the Basin water budget. This presentation will discuss the unique partnership used to complete this assessment including strategies to overcome data and information obstacles. Key findings, recommendations, and lessons learned will be presented that may be instructive for future work in the region, and provide a model for others regions seeking to gain a better understanding of their watershed for management and regulatory purposes. *Keywords: Decision making, Watersheds, Management.*

PITCHER, T.E.[1], FISK, A.T.[1], and HARING, M.[2], [1]Great Lakes Institute for Environmental Research, University of Windsor, Windsor, ON, N9B 3P4; [2]Department of Biological Sciences, University of Windsor, Windsor, ON, N9B 3P4. **Comparison of Isotopic Niche Widths Among Male Alternative Reproductive Tactics and Wild vs. Hatchery-produced Female Chinook Salmon From Lake Ontario.**

Hatchery-produced salmon often differ from their wild counterparts in many metrics including behavior, growth, reproductive success and survivorship, but our understanding of their trophic ecology is limited. We used stable isotopes of carbon ($\delta13C$) and nitrogen ($\delta15N$) to examine whether: (1) hatchery-produced female Chinook salmon from Lake Ontario would be similar in trophic level and carbon source utilization to wild females and (2) there were differences in trophic levels and carbon sources between wild males from the alternative reproductive tactics (which include smaller precocious jacks and larger and older hooknoses). Wild and hatchery raised females fed at the same trophic level and similar carbon sources based on $\delta15N$ and $\delta13C$, respectively, although wild individuals had a larger isotopic niche width. Jack and hooknose males had similar isotopic niche widths and feed at the same trophic level, jacks had higher δ13C that suggests greater reliance on nearshore or benthic resources. These results will be discussed in light of the hatchery stocking practices of Lake Ontario and also in the evolutionary context of alternative reproductive tactics. *Keywords: Salmon, Alternative reproductive tactics, Lake Ontario, Hatchery, Isotope studies, Diets.*

PLACH, J.M.[1], LIN, S.[1], DROPPO, I.G.[2], and WARREN, L.A.[1], [1]School of Geography and Earth Sciences, McMaster University, 1280 Main Street West, Hamilton, ON, L8S 4K1; [2]National Water Research Institute, Environment Canada, P.O. Box 5050, Burlington, L7R 4A6. **Iron Cycling in a Littoral Freshwater Beach: Implications for Floc Trace Metal Dynamics.**

This field-based study demonstrates that highly dynamic trace metal (Ag, Co, Cu, Pb) behavior in suspended floc and the sediment surface fine-grained lamina (SFGL) is linked specifically to Fe mineral cycling between these two compartments driven by rapidly fluctuating energy-regimes in a shallow littoral beach in Lake Ontario. Water, floc, SFGL and bed sediments samples were collected at Toronto Sunnyside Beach, during two 12-hour sampling campaigns (July 21, 2010; August 10, 2011) to investigate potential spatial and temporal variation in physicochemical conditions affecting Fe abundance and metal behaviour of flocs and surficial sediments along a spatial transect from nearshore to offshore. Results reveal distinct, Fe mineral controls on trace metal sequestration patterns under quiescent conditions. Higher metal sequestration occurred in floc associated with amorphous Fe oxyhydroxides (FeOOH), while less reactive crystalline Fe oxides (FeOx) dominated bed metal sequestration. Spatial and temporal shifts in energy-regime governing floc settling/sediment erosion controlled the mixing of FeOOH/FeOx, resulting in discernible, hydrodynamic-dependent floc and SFGL metal associations. Further, temporal shifts in secondary environmental parameters (photosynthetic-driven pH) influenced overall floc sorption behaviour. *Keywords: Hydrodynamics, Iron, Metals.*

PORTISS, R.[1], ROUS, A.[2], MIDWOOD, J.D.[2], VEILLEUX, M.A.N.[2], LAPOINTE, N.W.R.[2], SCISCIONE, T.[1], WELLS, M.G.[3], DOKA, S.E.[4], and COOKE, S.J.[2], [1]Toronto Region Conservation, 5 Shoreham Drive, Toronto, ON, M3N 1S4; [2]Carleton University, 1125 Colonel By Dr, Ottawa, ON, K1S 5B6; [3]University of Toronto, 1265 Military Trail, Toronto, ON, M1C 1A4; [4]Fisheries and Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **Multispecies use of restored fish habitat in Toronto Harbour.**

Widespread development has led to impairment of freshwater coastal embayments, which provide critical and unique habitat for most fish species. In the Toronto Harbour Area of Concern (AOC), restoration efforts have been directed towards improving the amount and quality of fish habitat in the harbour. In order to evaluate the effectiveness of this restoration work, it is important to determine whether both target species and the fish community as a whole are using restored areas. From 2010 to 2013, individuals from 8 species (walleye, northern pike, largemouth bass, common carp, bowfin, yellow perch, white sucker, and brown bullhead) were tagged and tracked using a large acoustic telemetry array in Toronto Harbour. We present results from this ongoing embayment-wide study evaluating: 1) the use of restored areas by these 8 species based on residency time and 2) species-specific movement patterns among coastal embayments and between the inner and outer harbours. Results from this study will help determine the success of past restoration efforts and inform the development of future restoration projects in the Toronto Harbour AOC. *Keywords: Acoustics, Habitats, Fisheries.*

POTHOVEN, S.A.[1] and MADENJIAN, C.P.[2], [1]NOAA-GLERL, Muskegon, MI, 49441; [2]USGS Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105-2807.
**Piscivory by Lake Whitefish in Lake Huron.**

We evaluated the diet of lake whitefish in Lake Huron during 2002-2011 to determine the importance of round goby and other fish as prey items. The overall percentage of adult lake whitefish in Lake Huron that had eaten fish increased from 10% in 2002-2006 to 20% in 2007-2011, with a corresponding decrease in the frequency of dreissenids from 52 to 33%. During 2002-2006, round goby (38%, wet mass), sculpins (34%), and ninespine stickleback (18%) were the primary fish eaten, whereas round goby accounted for 92% of the fish eaten in 2007-2011. Overall, round goby were found in the fewest lake whitefish stomachs in the north region (6%) and the most in the central (23%) and south (19%) regions. In the central region, round goby were eaten during all seasons that were sampled (spring through fall), but in the south region, round goby were eaten only in winter and spring, but not in the summer, when dreissenids and *Bythotrephes* dominated the diet. Based on the 2007-2011 diet composition, an individual lake whitefish would need to have increased consumption relative to 1983-1994 by 6% in the north region, 12% in the central region, and 41% in the southern region in order to achieve the same growth that was observed before dreissenid mussels arrived. *Keywords: Lake Huron, Fish diets, Fisheries.*

PURIC-MLADENOVIC, D.[1], GEE, K.[2], MARTIN, A.[3], and HERNANDEZ, P.[4], [1]MNR, 300 Water St., Peterborough, ON, K9J 8M5; [2]MNR, 2284 Nursery Rd., Barrie, ON, L0L 1X0; [3]University of Toronto, 33 Willcocks St, Toronto, ON, M5S 3B3; [4]MNR, 50 Blooming-ton Rd, Aurora, ON, L4G 0L8. **Terrestrial Monitoring in the Lake Simcoe Watershed.**

It is expected that land development, environmental and climate change pressures will put additional stress on already altered natural heritage systems and terrestrial vegetation in the Lake Simcoe watershed. As a result, there has been a growing need to preserve and improve the existing environment, ensure steady flow of ecological goods and services through integrated landscape planning, conservation and adaptive management actions. However, the strength and success of these activities depends, among others, on the amount, health and quality of terrestrial vegetation, and timely detection of any changes in any of these. A consistent vegetation inventory and monitoring information is necessary to establish a baseline terrestrial condition, support monitoring and reporting across different spatial and temporal scales, satisfy both the existing and future diverse data needs and demands, and inform diverse decision-making needs. This presentation presents a method for deriving and testing a set of monitoring criteria that are readily obtainable from field collected information and incorporating them with GIS based landscape data. This plot based inventory approach enabled the vision and planning for a strategic terrestrial monitoring design across the watershed.

# Q

QUINN, J.S.[1], PYENBURG, B.[1], and MOORE, D.J.[2], [1]Biology Department, McMaster University, 1280 Main Street West, Hamilton, ON, L8S 4K1; [2]Canadian Wildlife Service, Canada Centre for Inland Waters, 867 Lakeshore Road,, Hamilton, ON, L7R 4A6. **Reterning Windermere Basin.**

Windermere Basin in the south-eastern end of Hamilton Harbour recently underwent a large-scale wetland restoration. During the construction, from 2010 through 2012, colonial nesting birds, including common terns, *Sterna hirundo*, were excluded from the construction area to avoid legal implications related to disturbance of nesting birds. As part of the project, three new islands were built as habitat for common terns, a species of concern in the lower great lakes. A forth island, "Spur dike island", which had been used for nesting common terns between 1991 and 2009, was strengthened and resurfaced as additional tern habitat. Here we report on our efforts to attract common terns back to this nesting habitat

after three years of exclusion from the site. We used three sound systems along with common tern decoys in an attempt to lure the terns to the islands that had been designed for them. Terns nested on three of the four islands during the 2013 breeding season. The location and design of the habitat probably had the greatest role in re-terning Windermere basin. The creation of this protected breeding habitat and the rapid re-colonisation by common terns is an encouraging step toward stabilising the local breeding population, a delisting criterion for beneficial use impairments under the HHRAP. *Keywords: Avian ecology, Re-colonisation, Conservation, Remediation.*

# R

RACHOL, C.M. and FOGARTY, L.R., U.S. Geological Survey, Michigan Water Science Center, 6520 Mercantile Way, Suite 5, Lansing, MI, 48911. **Event Sampling in a Nutrient Limited System, Thunder Bay River Watershed, Alpena County, MI, 2012.**

The US Geological Survey collected synoptic samples within the Thunder Bay River watershed in 2012 as part of the Coordinated Science and Monitoring Initiative. This sampling effort provided a characterization of nutrient and sediment concentrations at five locations within the watershed during six storm events. Three sampling sites are located upstream of three large impoundments, one sampling site is located below two of the impoundments, and the remaining sampling site is below all impoundments (approximately 1.5 km upstream of the river mouth into Thunder Bay). Samples were analyzed for major nutrients (nitrogen and phosphorus species) and suspended sediment, streamflow was measured during sample collection at each location, and instantaneous loads were calculated. Evaluation of these data shows that there is a significant difference in concentration of particulates above versus below the impoundments. Median concentrations for total phosphorus and total nitrogen were higher in samples collected from the upstream sampling sites than those from the downstream sites. Nutrient concentrations, estimated loads, and a general discussion of the perceived effects of the impoundments on loads will be presented. *Keywords: Water quality, Nutrients.*

RAMIN, M.[1], MIDLANE-JONES, S.[2], MUGALINGAM, S.[2], GEATER, K.[3], MORLEY, A.[4], and ARHONDITSIS, G.B.[1], [1]University of Toronto, Ecological Modelling Laboratory, Toronto, ON, M1C 1A4; [2]Lower Trent Conservation, Trenton, ON; [3]Environment Canada, Toronto, ON; [4]Ontario Ministry of the Environment, Kingston, ON. **Coupling Public**

**Perception and Stakeholder Engagement with the Water Quality Criteria Setting Process in the Bay of Quinte.**

In this project, our aim is to address the urgent need for novel policy analysis tools that can effectively support environmental management by illustrating how Bayesian inference and decision theory can provide a coherent framework for model-based management of natural resources. In Bayesian decision theory, management objectives can be evaluated by integrating the probability of achieving a given environmental goal with utility functions that reflect different socioeconomic costs and benefits. The case study for this research is the Bay of Quinte in the northeastern shore of Lake Ontario. A major undertaking of this research is to engage public, local stakeholders, variety of government, private sector, community participants and policy makers that are involved with the Bay of Quinte RAP. Our research will use expert elicitation and public input to identify the water quality criteria that effectively balance between environmental concerns and socioeconomic values. The public survey was conducted throughout the summer of 2013. We completed a total of 721 surveys of local residents and tourists. The public identified the algal scums and the integrity of fish populations as the two most important water quality issues in the Bay of Quinte. A second survey is designed specifically for local decision makers and stakeholders. *Keywords: Water quality, Environmental criteria, Public participation, Bay of Quinte, Environmental policy, Environmental modeling.*

RASHID, I.O.[1], ENGLISH, M.C.[1], SCHIFF, S.L.[2], PETRONE, R.[2], SPOELSTRA, J.[2], and BASU, N.B.[2], [1]Wilfrid Laurier University, Waterloo, ON; [2]University of Waterloo, Waterloo, ON. **Evaluation of the Soil and Water Assessment Tool (SWAT) model applicability in a first-order agricultural watershed in southern Ontario.**

The Soil and Water Assessment Tool (SWAT) model was modified and parameters defined to simulate the effects of tile drainage on flow and nitrate ($NO3^-$) export from small watersheds during the four seasons characteristic of southern Ontario. This study compares differences and similarities between real-world watershed processes and management decisions against model output by: (1) utilizing the SWATtile model for comparison of simulated to measured discharge from a watershed and tiled field using several years of data; (2) utilizing the model for comparison of simulated to measured $NO3^-$ from a watershed and tiled field; and (3) how modifications to tile spacing (density) can be manipulated to achieve a balance between improving soil drainage while limiting $NO3^-$ export. The effects of tile density changes were evaluated for several seasons to determine the impact of moisture availability (for tile flow) as precipitation undergo phase change cycles from rain to snow and back to rain. As with all watershed models, SWAT has its shortfalls with parameter settings that may require site specific empirical values. This research has demonstrated that SWAT model can be a useful tool for agricultural watershed management and enhance crop productivity with proper incorporation of long-term flow and $NO3^-$ measurements. *Keywords: Management decisions, Model studies, Tile drainage, Water quality, Watersheds, Nitrate.*

RAYMER, Z., SHUCHMAN, R.A., SAYERS, M., FAHNENSTIEL, G.L., and BROOKS, C.N., Michigan Tech Research Institute, 3600 Green Ct. Suite 100, Ann Arbor, MI, 48105. **Mapping Harmful Algal Blooms in the Laurentian Great Lakes: An Analysis of HAB Occurrences Since 2002.**

Harmful Algal Blooms (HABs) occurrence in the Great Lakes is becoming increasingly problematic as they occur more frequently, in larger areas, and with rising severity. Remote sensing that utilizes both satellite and airborne imagery has been effectively used to map and monitor HAB events in the Great Lakes in order to help decision makers understand the extent of the problem. The mapping algorithm uses MODIS satellite imagery to identify areas of high chlorophyll concentration as well as areas of floating scum. The mapping algorithm was used to process cloud free imagery covering Green Bay, WI, Saginaw Bay, MI and the Western Basin of Lake Erie, MI/OH from 2002 through the fall of 2013. The resultant time series for each AOC was analyzed to show trends in HAB onset/offset dates, trends in average total HAB area for each year as well as average floating extent and average high chlorophyll area extent. The time series study was also able to highlight locations within each study area that are consistently plagued by long-term HAB inundation. Together, these spatial and temporal measures were used to show how harmful algal blooms have changed over time. *Keywords: Harmful algal blooms, Time series, Monitoring, Remote sensing.*

RAZAVI, N.R.[1], ARTS, M.T.[2], QU, M.[1], JIN, B.[3], REN, W.[4], WANG, Y.[1], and CAMPBELL, L.M.[5], [1]Department of Biology, Queen's University, Kingston, ON, K7L 3N6; [2]Department of Chemistry and Biology, Ryerson University, Toronto, ON, M5B 2K3; [3]Center for Watershed Ecology, Nanchang University, Nanchang, 330031, China; [4]Key Laboratory of Yangtze River Water Environment, Tongji University, Shanghai, China; [5]Environmental Science, Saint Mary's University, Halifax, NS, B3H 3C3. **Effect of Eutrophication on Methylmercury, Selenium and Fatty Acid Content in Bighead Carp *Hypophthalmichthys nobilis* .**

Quantifying the effect of eutrophication on mercury (Hg), selenium (Se) and essential fatty acids (EFA) in fish is necessary to find how risk-benefit ratios (e.g. Se:Hg, EFA:Hg) vary with productivity. Total Hg and methylmercury (MeHg), Se and EFA eicosapentaenoic acid (EPA, 20: 5ω3) and docosahexaenoic acid (DHA, 22:6ω3) were analyzed in Bighead carp (*Hypophthalmichthys nobilis*) dorsal muscle tissue from subtropical reservoirs of eastern China along a gradient of eutrophication. Individual elements and EFA, as well as risk-benefit ratios were regressed against total phosphorous (TP), chlorophyll-a (chl-a) and phytoplankton species composition. We found low Hg concentrations (MeHg range = 0.01 - 0.11 μg/g ww) and Se:Hg molar ratios well above the protective level (Se:Hg >1). Fatty acid profiles showed bighead carp had a high content of both EPA and DHA (9.5 and 20.1%, respectively). However, fish from reservoirs with higher TP had significantly lower Se:Hg and fish from reservoirs with higher chl-a had significantly lower EPA content. Phytoplankton species composition predicted Se concentrations only. These findings suggest that eutrophication can affect different aspects of element and fatty acid accumulation into planktivorous fish, and ultimately may result in fish of lower nutritional value relative to MeHg.
*Keywords: Fatty acids, Eutrophication, Selenium, Mercury, Reservoirs, Carp.*

REAVIE, E.D.[1] and HEATHCOTE, A.J.[2], [1]Natural Resources Research Institute, University of Minnesota Duluth, Duluth, MN, 55811; [2]Département des Sciences Biologiques, Université du Québec à Montréal, Montréal, QC, H3C 3P8. **Indicators Require Exhaustive Testing: An Example Using Diatoms and Phosphorus.**

Many existing transfer functions are based on weak species-environmental relationships that are confounded by secondary variables, resulting in poor predictive power. We evaluated diatoms from phytoplankton samples in the development of a total phosphorus (TP) transfer function based on weighted-average species abundance. Several tests were applied to validate our new indicator. Of the 118 common diatom taxa 76% had non-monotonous responses along the Great Lakes TP gradient. However, there was substantial autocorrelation among samples, justifying the need for further validation. A randomization procedure indicated that the actual transfer function consistently performed better than simulated functions. Further, TP was minimally confounded by other environmental variables. We then hindcasted TP using fossil diatom assemblages in a Lake Superior sediment core. Passive, multivariate analysis of the fossil samples against the training set data indicated that TP was a major determinant of historical diatoms, verifying that the function was well suited to reconstruct past TP. Collectively, these results show that diatom coefficients for water quality are robust indicators of Great Lakes condition. We recommend use in management when retrospective data are needed for tracking long-term degradation, remediation and trajectories. *Keywords: Phytoplankton, Indicators, Diatoms.*

REDDER, T.M., DEPINTO, J.V., RUCINSKI, D.K., and TAO, H., LimnoTech, 501 Avis Dr., Ann Arbor, MI, 48108. **Assessing the Impact of Potential Climate Change on Shoreline Ecosystems of the Upper Great Lakes with an "Integrated Ecological Response Model".**

The International Upper Great Lakes Study Board recently completed a study for the International Joint Commission to evaluate the impacts of Lake Superior regulation plans and basin supply scenarios on the ecosystem and various economic sectors. In support of the decision process, an "Integrated Ecological Response Model" (IERM2) has been developed to evaluate the potential ecological impacts of plausible future basin supply scenarios and regulation. The IERM2 model, which synthesizes the research of scientists comprising the Ecosystems Technical Working Group, quantifies the cause-effect relationship between hydrologic conditions and ecosystem "performance indicators". A suite of more than 30 performance indicators represents a range of coastal ecosystem components, including wetland vegetation, macroinvertebrates, fish, and birds. A "Coping Zone" analysis is included to evaluate the potential for significant harm to the near-shore ecosystem to occur as a result of extreme hydrologic conditions, including those resulting from potential climate change in the region. *Keywords: Ecosystem modeling, Water level fluctuations, Climate change.*

REID, K.B.[1] and NUDDS, T.[2], [1]Ontario Commercial Fisheries' Association/University of Guelph, 45 James Street, Blenheim, ON, N0P 1A0; [2]Department of Integrative Biology, University of Guelph, Guelph, ON. **Risk assessment of alternative seasonal harvest strategies for the Lake Erie walleye (Sander vitreus) fishery: Does it matter when fish are harvested?**

Commercial harvesting in the Lake Erie walleye fishery is seasonally controlled. An initial quota (IQ) is allocated to the fishery for the period of 1 January to 1 May when a final quota is allocated for the remainder of the year. Based on a precautionary approach, the initial allocation is set as a relatively small proportion of the final quota (mean % 1990-2013). Agency rational for this precautionary approach includes uncertainty about the level of protection of the spawning stock biomass that may be necessary for sustainability. A model that accounts for uncertainty in the walleye stock-recruit relationship was used to analyze the consequences of alternative IQ management decisions. Uncertainty in the stock-recruit relationship was considered using a Bayesian approach to parameter estimation. An age-structured model was developed to evaluate risk of the population falling below specific thresholds, associated with various IA management decisions. Our primary task was to provide science-based advice by evaluating how the walleye population dynamics may respond to alternative IQ harvest strategies. Our results show that as long as the fishing mortality rate is low (less than F=0.2), IAs of up to 70 % of total annual harvest can be taken before spawning without imposing a significant risk to sustainability. *Keywords: Decision making, Fisheries, Management.*

REID, K.B., Department of Integrative Biology, University of Guelph, Guelph, ON. **Evolving toward an interdisciplinary approach to fisheries management.**

Incorporating the human dimensions of fisheries into the management process will require management to evolve toward an interdisciplinary approach. The broadest forms of interdisciplinarity range across the full spectrum of disciplines from the natural sciences to the humanities. Barriers to broad interdisciplinarity in fisheries management have proven difficult to overcome, but new tools and techniques are contributing to bridge these barriers and move fisheries management toward broad interdisciplinarity. There is emerging evidence that Bayesian philosophy and methods are well suited to this purpose. The utility of Bayesian philosophy and methods for the integration of knowledge, from a wide range of humanities and natural science disciplines, into fisheries management is discussed. Examples of the application of these tools from elsewhere, and from our own work on Lake Nipigon, are used to outline the benefits of using Bayesian philosophy and methods to evolve toward a broad interdisciplinary approach to fisheries management. *Keywords: Bayesian methods, Interdisiplinary, Hermeneutics.*

REZANEZHAD, F.[1], VAN CAPPELLEN, P.[1], ROBINSON, C.[2], DÜRR, H.[1], SMEATON, C.[1], MESQUITA, M.[1], THRASHER, K.[1], and BACCA-CORTES, G.[1], [1]Ecohydrology Research Group, University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L 3G1; [2]Department of Civil and Environmental Engineering, Western University, London, ON. **Groundwater Quality at Beaches of the Great Lakes.**

Groundwater discharge as a pathway for delivering nutrients and contaminants can have a significant impact on the ecological health of the Great Lakes. In our study, we focus on the spatial and temporal distributions of water quality parameters beneath four beaches of Lake Ontario (Marie Curtis and Burlington) and Lake Huron (Mountain View and Balm).

The locations of the beaches range from relatively pristine rural to heavily human-impacted urban settings. At each site, groundwater was sampled along a transect perpendicular to the shoreline, with additional pore water sampling on both sides of the transect to assess alongshore variability. Sampling was carried out in early-, mid- and late-summer of 2013. In this presentation, we analyze the measured distributions of groundwater nutrients (C, N, P, S and Si) to delineate the relative roles of landward and lake inputs, physical mixing processes and biogeochemical reactions. *Keywords: Nutrients, Water quality, Geochemistry.*

RICHARDS, R.P.[1] and DOLAN, D.M.[2], [1]National Center for Water Quality Reseach, Heidelberg University, Tiffin, OH, 44883; [2]University of Wisconsin - Green Bay, Green Bay, WI, 54311. **Seasonality in Phosphorus Loading to Lake Erie from the Maumee River.**

In an earlier paper, we explored the "pulse" of phosphorus loading to Lake Erie in 1996-1998, when total loads were larger than in surrounding years, exceeding the target load all three years. We found that the relationship between the log of total phosphorus (TP) and the log of discharge (Q) was different in winter than in summer, particularly for the Maumee River, a major source of phosphorus loading. The linear relationship is steeper in winter than in summer, thus large flows in winter carry more phosphorus than equivalent summer flows. Major winter runoff in these years produced above average loads. Here we extend that analysis to more recent years and to particulate phosphorus (PP) and dissolved reactive phosphorus (DRP). Our analysis shows that the two-season model still holds, and applies even more strongly to PP than to TP: the difference between the seasons is more pronounced. The relationship between log(DRP) and log(Q) also shows seasonal differences, but the slope for summer is steeper than that for winter. One practical consequence of these seasonal patterns is that sampling programs that operate only during the warm season will provide a distorted picture of tributary loading - one that tends to underestimate TP and PP and overestimate DRP. *Keywords: Phosphorus, Tributaries, Lake Erie.*

RIDGWAY, M.S. and MIDDEL, T.A., Harkness Laboratory of Fisheries Research, Ontario Ministry of Natural Resources, Trent University, Peterborough, ON, K9J 7B8. **Coastal Zone Occupancy by Double-Crested Cormorants on Lake Huron Before, During and After a Food Web Regime Shift.**

The coastal occupancy patterns of double-crested cormorants (*Phalacrocorax auritus* ) before (2001-2002), during (2003) and after (2004-2005) a regime shift in Lake Huron provided an opportunistic examination of how changes in distribution match theoretical expectations of system behaviour through a regime shift process. In the year prior to the regime shift (2002), model selection indicated a number of plausible models based on a set of habitat covariates. Cormorants were widely distributed without clear spatial structure. The same covariates provided strong weight of evidence in years before and after the regime shift for a limited model set. This uncertainty in model strength in the year prior to the regime shift is interpreted as indicative of increased spatial correlation of foraging cormorants prior to the regime shift - a strong signal of a tipping point for this coastal predator and its food web. Annual shifts in the magnitude and sign of habitat coefficients indicated movement of cormorants between two coastal regions in Lake Huron. This was especially the case in the regime shift year. Habitat occupancy of large mobile predators and associated model selection offers one avenue for increasing our ability to forecast periods of critical transition that define aquatic regime shifts. *Keywords: Lake Huron, Coastal ecosystems, Cormorants.*

RIEFF, B.W.[1], DELORENZO, S.[2], TRIPLETT, T.[2], SANSOM, R.[2], WOLFE, P.[1], and NELSON, H.[1], [1]Fluid Imaging Technologies, Inc, 200 Enterprise Drive, Scarborough, ME, 04074; [2]Clackamas River Water, 16770 SE 82nd Drive, Clackamas, OR, 97015. **Semi-automated identification of plankton and biovolume calculation.**

Responding to the need for the "rapid counting and measurement of individual plankton cells in natural populations", researchers at the Bigelow Laboratory for Ocean Sciences in 1999 developed an imaging flow cytometer (FlowCAM) designed specifically to support aquatic microbial research. Fifteen years later, the need for rapid and precise methods that provide a means to better understand plankton community structure and size is of critical importance in developing an understanding of the effects of climatic change on ecosystems, harmful algal blooms, freshwater microbial food webs and more. Here we present an update on recent advances made to the FlowCAM's software that specifically address the image recognition and semi-automated capabilities of the technology for the classification of plankton and estimation of plankton biovolume. Included will be an overview of the methodology along with a review of data from recent studies. *Keywords: Plankton, Algae, Measuring instruments.*

RILEY, A.E. and KAMMIN, L.K., Illinois-Indiana Sea Grant, 1101 W. Peabody Dr., Urbana, IL, 61801. **Shining a Light in the Black Box: Effectively Communicating the Science Behind Pharmaceutical and Personal Care Product Pollution.**

Concerns surrounding pharmaceuticals and personal care product (PPCP) pollution are garnering increased attention from both public officials and popular media. This interest, coupled with the complex and dynamic nature of PPCP research, creates a vital need for officials, the media, and citizens at large to have access to up-to-date information that accurately presents what is known and unknown about these contaminants in ways that appeal to them. Illinois-Indiana Sea Grant (IISG) has developed a multifaceted outreach and communication strategy to help these audiences understand the science behind PPCP pollution and the roles they play in protecting aquatic ecosystems. Using videos, websites, blogs, researcher interviews, social media, and public exhibits, IISG introduces audiences to concerns at the heart of PPCP research, such as impacts to wildlife, wastewater treatment strategies, risks of chemical by-products, limits in sampling methods, and policy implications. The wide array of materials helps users turn individual studies into a more complete picture of the issue and allows them to hear directly from researchers about ongoing and future work. This comprehensive strategy helps audiences engage with PPCP science and related conservation efforts and stands as a model for other outreach programs. *Keywords: Education, Communications, Outreach, Environmental contaminants.*

RITCHIE, K.V., GEARHART, T.A., STOCKWELL, J.D., and KRAFT, J., University of Vermont, Rubenstein Ecosystem Science Laboratory, Burlington, VT, 05401. **Do Cyanobacteria Blooms Short-Circuit Essential Fatty Acid Transfer to Fish?**

Cyanobacteria blooms are a growing concern in the Great Lakes and across the globe. Blooms affect tourism and recreation, water potability, and property values, with some species capable of producing harmful toxins that cause health issues. Cyanobacteria blooms also disrupt food web dynamics. Essential fatty acids (EFAs) are key nutrients that aid in many basic biological processes. In aquatic systems, phytoplankton are the main producers of EFAs - animals ultimately rely on phytoplankton to maintain sufficient levels of EFAs. However, cyanobacteria are low in EFAs. Consequently, EFA transfer to higher trophic levels may be short-circuited during blooms. In laboratory experiments, cyanobacteria-fed zooplankton demonstrated poor growth and reproduction because of low EFA levels. A common, but untested, hypothesis is that cyanobacteria blooms will short circuit the transfer of EFAs up the food web to fish. We tested this hypothesis by analyzing the EFA content of yellow perch, white perch, and seston from four locations on Lake Champlain with varying intensities of cyanobacteria blooms in June (pre-bloom), August (bloom), and October (post-bloom). Our results will inform the broad-scale question whether cyanobacteria blooms negatively impact EFA levels in fish. *Keywords: Harmful algal blooms, Essential fatty acids, Yellow perch, Food chains.*

RITZENTHALER, A.A.[1], KRAMER, E.L.[1], FRY, L.M.[1], and ANDERSON, E.J.[2], [1]Cooperative Institute for Limnology and Ecosystem Research (CILER), Ann Arbor, MI; [2]NOAA Great Lakes Environmental Research Laboratory (NOAA GLERL), 4840 S State Rd, Ann Arbor, MI, 48108. **Understanding Spatial and Temporal Variability in Near-shore Bacterial Water Quality and its Implications on Effective Beach Management.**

Based on guidance from the U.S. Environmental Protection Agency, the Michigan Department of Environmental Quality sets the regulatory limit which fecal indicator bacteria (FIB), specifically *E. coli*, concentration must remain below in order for a body of water to be determined safe for public recreation (i.e. swimming). Although beach management decisions are guided by FIB monitoring results, the collection of near-shore water quality samples is hardly uniform within or between beach monitoring programs. Utilizing a robust data set collected from Macomb County, Michigan during the 2012 and 2013 swimming seasons, we explore variability in the spatial and temporal distribution of FIB. Utilizing potential drivers of variability, both observed and modeled, we present the results of regression based analyses characterizing variability in *E. coli* concentration among and within sampling sites. By understanding where variability exists, and the scale at which it acts, we can better understand the implications monitoring program design has on beach management decisions. A greater understanding of variability can also be used help inform the spatial and temporal scales at which water quality models need to operate in order to provide meaningful outputs for use as decision support tools in the face of monitoring budget cuts. *Keywords: Lake St. Clair, Monitoring, Human health.*

ROBERTSON, D.M.[1], SAAD, D.A.[1], BENOY, G.A.[2], JENKINSON, W.[3], and JOHNSTON, C.M.[4], [1]U.S. Geological Survey, Wisconsin Water Science Center, 8505 Research Way, Middleton, WI, 53562; [2]International Joint Commission, Canadian Section, 234 Laurier Ave. West, Ottawa, ON, K1P 6K6; [3]National Research Council of Canada, 1200 Montreal Rd., Ottawa, ON, K1A 0R6; [4]U.S. Geological Survey, NH/VT Water Science Center, 331 Commerce Way, Pembroke, NH, 03275. **SPARROW Watershed Modeling of the Entire Great Lakes Basin.**

To help address eutrophication problems in the Great Lakes, SPARROW (SPAtially Referenced Regression On Watershed attributes) models were recently developed to simulate phosphorus (P) and nitrogen (N) loading in tributaries from the U.S. part of the Great Lakes Basin. Model results were used to: 1) estimate U.S. loads to each Great Lake; 2) rank all U.S. tributaries based on loads and yields; and 3) estimate the relative importance of each of the known nutrient sources. To provide a more complete description of P and N loading from the entire watershed of each Great Lake, a binational modeling effort is now underway to develop SPARROW models for the entire Great Lakes Basin. These models are being developed using much smaller catchments (basins and stream network delineated using NHD Plus and NHN) to enable improved spatial descriptions of where and from what sources the P and N originate. The models will be calibrated using loads from sites monitored by U.S. and Canadian organizations, including data from smaller watersheds than used in previous models. To enable seamless model input and descriptions of SPARROW output information, harmonized geospatial coverages are being developed for the streamflow network, nutrient sources, and the environmental characteristics used in the models. *Keywords: Nutrients, Model studies, Pollution sources.*

ROBICHAUD, C.[1], ROONEY, R.C.[1], and RICHMAN, S.[2], [1]University of Waterloo, 200 University Ave. West, Waterloo, ON, N2L 3G1; [2]Long Point Waterfowl, P.O. Box 160 Courier, 115 Front Street, Port Rowan, ON, N0E 1M0. ***Phragmites australis* Establishment and Bird Communities at Long Point, Ontario.**

The Long Point marshes constitute 70% of wetland habitat on the Canadian side of Lake Erie and represent a migratory bird staging area of continental importance. Their role as vital habitat for migratory birds is threatened, however, by the on-going invasion of non-native *Phragmites australis*. The dense, impenetrable monocultures characteristic of established *Phragmites* stands could imperil species at risk (e.g., Least Bittern). Yet results of research carried out 10 years ago, during the early stages of *Phragmites* invasion, suggest that impacts on bird use are minor or even beneficial. We will test whether the effects of *Phragmites* invasion in Long Point remain minor, now that the invasion is more established. Repeating the work done in 2001/2, we anticipate finding that bird use in *Phragmites* infested areas will be reduced relative to pre-invasion or early-stage invasion rates. Further, we anticipate major changes in bird community composition associated with established *Phragmites* stands. This new project will commence in May 2014. We seek comments and feedback on our approach and potential opportunities for future collaboration. *Keywords: Waterbird, Ecosystem health, Birds, Vegetation, Invasive species.*

ROBINSON, J.M.[1], NEFF, M.R.[2], and BHAVSAR, S.P.[2], [1]University of Toronto, Toronto, ON; [2]Ontario Ministry of the Environment, Toronto, ON. **Assessment of contaminant levels in fish from the Toronto waterfront area.**

The Toronto and Region Area of Concern (AOC) has a history of elevated contaminant levels in fish, and, as a result, restrictive fish consumption advisories. Data collected by the Province of Ontario was used to investigate long-term (1975-2011) temporal trends of mercury, polychlorinated biphenyls (PCBs), mirex, and toxaphene levels in multiple fish species collected from the Toronto waterfront area. Recent (2000-2012) fish mercury and PCB levels were compared to those for other areas of the Great Lakes, including AOCs. A historical comparison of fish PCB levels among Canadian AOCs was also conducted. Mercury and PCB levels in multiple species of fish from the Toronto waterfront area significantly declined over time, and recent mercury levels are well below the current consumption advisory benchmarks. However, despite declines, PCB levels remain above the current consumption advisory benchmarks and above the levels observed in fish from other AOC and non-AOC regions of the Great Lakes. Half-life calculations for these species indicate that it may take 8-26 years for PCB concentrations in certain fish species to decline below the current consumption advisory benchmarks. Sustained monitoring of PCBs in fish from the Toronto waterfront area is recommended to aid in ensuring that recovery continues. *Keywords: Fish, Area of Concern, Pollutants, Toronto Waterfront, Lake Ontario.*

ROKITNICKI-WOJCIK, D.B., WATTON, P., and GRABAS, G.P., 4905 Dufferin St, Toronto, ON, M3H 5T4. **Referencing Coastal Wetland Habitat to Water Levels: Using Survey Science for Ecology in Lake Ontario.**

Water level regulation has been shown to considerably affect coastal wetland habitats and wildlife communities. To predict the effects of changing water level regimes in the Great Lakes requires a better understanding of the elevations occupied by vegetation communities. Water levels and coastal wetland data products (e.g. bathymetry and habitat modelling) are vertically referenced to International Great Lakes Datum (1985) (IGLD85), however there are few tools or guidelines to support the collection of accurate vertical data in Canadian coastal wetland settings, a subject typically reserved for surveyors. In this study, to support the adaptive management monitoring of coastal ecosystems of Lake Ontario, an approach was developed to collect accurate vertical data referenced to IGLD85 and investigate the relationship between water levels and coastal wetland habitat. Local benchmarks were created at study wetlands and survey-grade GPS and aquatic dataloggers were used to identify vegetation community zonation and local water levels. Results from surveys conducted from

2009-2012 demonstrate the accuracy of this approach. This study has wide applicability to Great Lakes science, and aims to provide guidance for biologists, who are outside the typical users of survey methods and technologies. *Keywords: Vegetation, Adaptive management, Coastal wetlands, Elevation, Water level.*

ROSAMOND, M.S.[1], VENKITESWARAN, J.J.[2], BAULCH, H.M.[1], CUMMINGS, T.F.[1], and SCHIFF, S.L.[1], [1]Dept. Earth & Environmental Sciences, University of Waterloo, 200 University Ave W., Waterloo, ON, N2L 3G1; [2]School of Environment & Sustainability, University of Saskatchewan, 11 Innovation Boulevard, Saskatoon, SK, S7N 3H5. **Seasonal Nitrous Oxide:Nitrate Relationships and Stream Order in Southern Ontario: Implications for Production Pathways and Management Strategies.**

Streams and rivers produce a significant portion of global anthropogenic nitrous oxide, a strong greenhouse gas, but controls on production are poorly understood. Nitrous oxide in rivers is primarily produced by microbes during nitrate reduction (denitrification). The United Nations Intergovernmental Panel on Climate Change provides linear equations relating nitrate and nitrous oxide to estimate nitrous oxide fluxes from streams, rivers and estuaries. However, strong nitrous oxide:nitrate relationships have been found in some streams but few rivers. In the Grand River, Ontario, nitrous oxide fluxes correlate most strongly with dissolved oxygen and temperature. To examine these relationships further, seasonal changes in the nitrous oxide:nitrate ratio in agricultural streams and rivers in southern Ontario were examined. Nitrate typically peaked in winter at all stream orders. However, nitrous oxide peaks occurred in winter and during storms in streams, but in summer at night in rivers. These differences suggest that the location and controls on nitrous oxide production change with stream order. Therefore, management strategies for nitrate and nitrous oxide should vary with stream order in order to maximize nitrate loss and minimize net nitrous oxide production. *Keywords: Grand River, Nitrous oxide, Nutrients, Nitrate, Geochemistry.*

ROWE, M.D.[1], VANDERPLOEG, H.A.[2], WANG, J.[2], ANDERSON, E.J.[2], NALEPA, T.F.[3], LIEBIG, J.R.[2], and JOHENGEN, T.H.[4], [1]NRC Research Associate, Great Lakes Environmental Research Laboratory, NOAA, 4840 S. State Rd., Ann Arbor, MI, 48108; [2]Great Lakes Environmental Research Laboratory, NOAA, 4840 S. State Rd., Ann Arbor, MI, 48108; [3]Graham Environmental Sustainability Institute, University of Michigan, 625 E. Liberty, Suite 300, Ann Arbor, MI, 48104; [4]University of Michigan - CILER, 4840 S. State Rd., Ann Arbor, MI, 48108. **Modeling the Effects of Stratification and Bathymetry on the**

**Interaction of Phytoplankton and Invasive Quagga Mussels in Nearshore Lake Michigan.**

The biomass of quagga mussels (*Dreissena rostriformis bugensis*) expanded in Lake Michigan after ~2004, coincident with reduced spring phytoplankton bloom. Previous studies have shown that quagga mussel grazing rates can outpace net phytoplankton growth, assuming a well-mixed water column. In addition, quagga mussels have been observed to reach a maximum biomass density at an optimal bathymetric depth of ~40 m. Several factors may contribute to the optimal depth for quagga mussels, including 1) cross-isobath transport of food particles by repeated resuspension and settling ("mid-depth sink"), and 2) influence of light-penetration, bathymetric depth, and stratification on the interaction between phytoplankton growth and mussel grazing. While other processes likely play a role, we explore the ability of the second factor to explain the observed spatial distribution of quagga mussels. We apply the 3-D, unstructured-grid, Finite-Volume Coastal Ocean Model (FVCOM) to simulate hydrodynamic transport and stratification, coupled to the General Ecological Model (GEM) to simulate phytoplankton growth. We added quagga mussel grazing effects based on observed grazing rates and spatial distribution. The mussel ration (mass of food intake per mussel biomass) is used to infer the simulated optimal depth habitat for quagga mussels.
*Keywords: Dreissena, Lake Michigan, Hydrodynamic model.*

RUTHERFORD, E.S.[1], VANDERPLOEG, H.A.[1], CAVALETTO, J.F.[1], LIEBIG, J.R.[1], MASON, D.M.[1], NALEPA, T.F.[2], JOHENGEN, T.H.[2], BURNETTE, D.[2], WELLS, D.[2], MABREY, K.[2], BUNNELL, D.B.[3], WARNER, D.M.[3], O'BRIEN, T.O.[3], and JOHNSON, J.E.[4], [1]NOAA GLERL, 4840 S. State Rd, Ann Arbor, MI, 48108; [2]University of Michigan CILER, 4840 S. State Rd., Ann Arbor, MI, 48108; [3]USGS-Great Lakes Science Center, 1451 Green Rd, Ann Arbor, MI, 48105; [4]Michigan DNR Alpena Fisheries Research Station, 160 E. Fletcher St, Alpena, MI, 49707. **The Effect of Spatial and Temporal Variability in Lower Food Web Dynamics on Larval Fish Feeding, Growth and Survival in Thunder Bay, Lake Huron.**

Changes in productivity of Great Lakes habitats from invasive species may influence early life history and recruitment of fishes. For example, dreissenid mussels have re-engineered nutrient and carbon flows, greatly reduced phytoplankton biomass and increased light transmittance. These changes may have differentially altered horizontal distributions, and vertical migrations and densities of zooplankton and fish larvae, thus potentially affecting larval fish feeding, growth and survival. In April, July, and September 2012, we sampled nutrients, fish larvae, and lower and upper food webs in Thunder Bay, LH on cross-isobath transects from 10 to 82 m using a variety of sampling gears. In April, we found nutrient concentrations and planktonic food web biomass were lowest nearshore (10m), but showed no difference from nearshore to offshore in July and September. In April, lake whitefish (LWF) larvae caught nearshore (10 m depth) grew poorly and consumed few prey, whereas in July, rainbow smelt (RBS) caught nearshore (18m) and bloater (BLT) larvae caught offshore (46 and 82 m) consumed a variety of zooplankton prey and grew well. Our results may help explain recent trends of poor LWF recruitment nearshore and improved recruitment of RBS and BLT offshore. *Keywords: Dreissena, Fisheries, Recruitment.*

RUTLEDGE, J.M., FRACZ, A.E., CARTWRIGHT, L.A., and CHOW-FRASER, P., McMaster University, 1280 Main Street West, Hamilton, ON, L8S 4K1. **Land Use Effects on Citizen Monitored URBAN Streams and Wetlands in Hamilton, Ontario.**

Wetlands and streams within city limits are prone to habitat destruction and degradation. This makes it essential for us to protect remaining habitat that are critical for ecosystem services in urbanized areas. The Urban-Rural Biomonitoring and Assessment Network (URBAN) is a citizen-science education and outreach program at McMaster University that trains and coordinates volunteers to contribute ecological monitoring data to environmental agencies. From 2010 to 2013, URBAN volunteers followed well-established protocols (Ontario Benthos Biomonitoring Network (OBBN), Marsh Monitoring Program (MMP)) to survey stream benthic invertebrates, marsh birds, and amphibians to assess the long-term effects of urbanization on natural areas. We used ArcGIS 10.2 to determine the proportion of urban land associated with each site. Urban land classes included transportation corridors, built-up pervious and impervious areas, whereas rural land classes included forest and marsh. We compared scores of the Hilsenhoff Biotic Index (HBI), species composition, as well as species richness and abundances across all sites. We found that decreasing site health was associated with increasing urban land use. Our results have important implications for conservation and emphasize the importance of protecting natural land surrounding streams and wetlands. *Keywords: Biomonitoring, Urbanization, Citizen science.*

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SAARINEN, J.A.[1], KOWALSKI, K.P.[2], TAYLOR, R.F.[3], PEARSALL, D.R.[3], MAY, C.A.[3], KEELING, R.W.[1], ANNIS, G.M.[3], and OPFER, S.E.[4], [1]The University of Michigan-Dearborn, 4901 Evergreen Road, Dearborn, MI, 48128; [2]U.S. Geological Survey - Great

Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105; [3]The Nature Conservancy of Michigan, 101 East Grand River, Lansing, MI, 48906; [4]NOAA Restoration Center- Great Lakes Region / Earth Resources Technology, 240 W. Lake St., Oak Harbor, OH, 43449.
**Western Lake Erie Restoration Assessment (WLERA): further understanding the potential and benefits of coastal wetland restoration.**

We assessed the restorability of present and potential coastal wetland areas along the U.S. shore of western Lake Erie basin (WLEB) to help identify, prioritize, and track wetland restoration investment on a regional scale. To accomplish this we used aerial image interpretations, expert formulations of multiple geospatial parameters, statistical modeling with measured observations, and feedback from regional managers and local stakeholders. Within our 195,621 ha study area between the mouths of the Detroit River, MI and Black River, OH, our model identified 1,834 ha (0.94%) as highly restorable wetland and 2,398 ha (1.23%) as restorable wetland. In the 2,045 km network of mapped hydrologic flowlines, 142 km (7%) of network was directly connected to WLEB, 435 km (21%) of network was interrupted by 1 disconnection, 606 km (30%) of network was interrupted by at least 3 disconnections, and 808 km (40%) of network was interrupted by at least 10 disconnections. Finally, we interpreted over 1,500 hydrologic disconnection points including culverts and gates, and over 3,000 km of dike features. These geospatial results are important to prioritization of future management decisions and restoration planning. Furthermore, this assessment provides the foundation for our ongoing investigation of ecological benefits with restoration. *Keywords: Lake Erie, Ecosystem modeling, Wetlands.*

SARGIS, G.M.[1], ADAMS, S.[1], and FLEMING, S.[2], [1]The Nature Conservancy, 1048 University Ave., Rochester, NY, 14607; [2]Ducks Unlimited, 6631 Reeves Road, Jordan, NY, 13080.
**Lessons Learned in Restoring Lake Ontario Coastal Wetlands through Habitat Creation and Control of Invasive Species.**

A number of wildlife species and community types have been declining in Lake Ontario coastal wetlands over the last few decades. This decline is linked to decreasing habitat quality from the expansion of dense homogenous stands of invasive cattail due to stabilized lake levels and a decrease of keystone species like muskrat. In 2010, The Nature Conservancy was awarded GLRI funding to help restore two coastal wetlands. In partnership with Duck's Unlimited we sought to improve access and restore habitat for three indicator species, northern pike, black tern and muskrat. This project compliments similar restoration work underway in the St. Lawrence Seaway and will be compared with lake wide monitoring of performance indicators related to a newly proposed water regulation plan for Lake Ontario. Wetland habitat was restored through the excavation of meandering channels and open water potholes, while invasive species throughout the region were mapped and managed. Based on two years of post-restoration monitoring we have concluded that properly designed channeling and potholing can be effective at creating and providing access to habitat. Recommendations for improving the success and implementation of similar coastal wetland restoration projects will be discussed in detail as will design pitfalls to avoid. *Keywords: Coastal wetlands, Invasive species, Experimental design.*

SAWTELL, R.W. and SAYERS, M., Michigan Tech Research Institute, 3600 Green Ct., Ste. 100, Ann Arbor, MI, 48105. **A Fast Algorithm for Automatic Removal of Mirror Side Banding From MODIS Oceancolor Imagery.**

MODIS imagery has long been plagued by optical errors (i.e. banding) introduced by the mirrors on board the spacecraft with a potentially significant impact on scientific study. Banding errors are most evident in the blue channels (412 nm, 440 nm, 490 nm) which are essential for chlorophyll retrieval algorithms. The error parameterization is also influenced by target and environmental factors that make it difficult to fully quantify spatially. The proposed algorithm analyzes a scene using Fourier transformation and computes a spatially dynamic correction factor. Resulting error is typically less than one percent of the underlying signal, tested by artificially introducing banding into a SeaWiFS scene which does not suffer from the mirror side banding problem. Visual analysis also confirms removal of the banding. The algorithm is robust and fast, allowing for batch processing of many scenes without need for manual tuning. *Keywords: Satellite technology, Remote sensing, Signal processing.*

SAWYER, J.M.[1], ARTS, M.T.[2], ARHONDITSIS, G.B.[3], and DIAMOND, M.[4], [1]Department of Geography, University of Toronto , 100 St. George St., Toronto, ON, M5S 2E5; [2]Department of Chemistry and Biology, Ryerson University, 350 Victoria Street, Toronto, ON, M5B 2K3; [3]4Department of Physical and Environmental Sciences, University of Toronto, 1265 Military Trail, Toronto, ON, M1C 1A3; [4]Department of Earth Sciences, 22 Russell St., Toronto, ON, M5S 3B1. **Exploring the Effects of Climate Change on the Transfer and Accumulation of Polyunsaturated Fatty Acids (PUFAs) on the Bay of Quinte's Food Web.**

Highly concentrated in fish, polyunsaturated fatty acids (PUFAs) are crucial for aquatic organisms because they affect metabolic activity, growth rates and reproduction. Climate change could have an impact on PUFA transfer through the aquatic food web as

PUFA quality can change depending on which phytoplankton proliferate. Cryptophytes and diatoms that prefer cold, oligotrophic waters contain an abundance of long-chain PUFAs (i.e. eicosapentaenoic acid: EPA; docosahexaenoic acid: DHA) whereas chlorophytes contain mostly shorter chain PUFAs (i.e. α-linolenic acid: ALA; linoleic acid: LIN; arachidonic acid). In contrast, cyanophytes that typify warmer, eutrophic waters are low quality algae that have virtually no long-chain PUFAs. A shift in the Bay's water temperature could increase the abundance of cyanophytes and decrease the abundance of diatoms and cryptophytes, subsequently decreasing the PUFA content and transfer up the food web. We have assembled a PUFA food web model that examines the food web transfer of PUFAs in aquatic freshwater organisms. Our model simplifies the physiologic reality of PUFA metabolism by considering the mechanisms of accumulation, egestion, transformation and β-oxidation. We examine climate scenarios to quantify their impact on PUFA transfer through the ecosystem from a bottom-up approach. *Keywords: Climate change, Polyunsaturated fatty acids (PUFAs), Bay of Quinte, Phytoplankton, Food chains.*

SAYERS, M.[1], SHUCHMAN, R.A.[1], LESHKEVICH, G.[2], and TRAUB, J.[1], [1]Michigan Tech Research Institute, 3600 Green Ct., Ste. 100, Ann Arbor, MI, 48105; [2]NOAA / GLERL, 4840 S. State Rd., Ann Arbor, MI, 48108. **Long Term Chlorophyll Observations in the Great Lakes from Oceancolor Satellite Data Using Multiple Retrieval Approaches.**

Ocean color satellites such as CZCS, SeaWiFS, MODIS, MERIS, and VIIRS have been imaging the Great Lakes and providing chlorophyll (chl) concentrations since 1979. Historically, the chl concentrations have been produced using an empirical band ratio technique developed by NASA for the open ocean. An alternative to the ratio technique is the use of semi-analytical Inverse Radiative Transfer Models (IRTM) such as the MTRI CPA-A. The IRTM approach requires knowledge of the optical properties of the Great Lakes and can provide more robust chl estimates in case II coastal waters where the color producing agents (CPAs) in the water include dissolved organic carbon and suspended minerals in addition to chl. Chl estimates from the NASA OC3 band ratio, CPA-A (IRTM), and EPA ship surveys were compared for the period 1998 to 2013. The comparisons which utilized SeaWiFS and MODIS satellite data show the changing water optical properties of the Great Lakes as a function of nutrient loading and invasive species presence. The comparison also indicated in the present day offshore areas of the Lakes where the dominant CPA is chl, the ratio and CPA-A methods both produce acceptable retrievals. In complex case II water such as Lake Erie and near shore regions throughout the Lakes the CPA-A estimates of chl are significantly more robust. *Keywords: Satellite technology, Chlorophyll, Phytoplankton, Remote sensing.*

SCHIFF, S.L.[1], SPOELSTRA, J.[1,2], SNIDER, D.M.[3], VENKITESWARAN, J.J.[1], CUMMINGS, T.F.[1], ROSAMOND, M.S.[1], ELGOOD, R.J.[1], CEJUDO, E.[1], SINE, S.S.[1], QUINN, J.M.[4], MOHAMED, M.[5], and ENGLISH, M.C.[6], [1]Department of Earth & Environmental Sciences, University of Waterloo, Waterloo, ON, N2L 3G1; [2]National Water Research Institute, Environment Canada, Burlington, ON, L7R 4A6; [3]School of Environmental Sciences, University of Guelph, Guelph, ON, N1G 2W1; [4]National Institute of Water and Atmospheric Research, PO Box 11115, Hamilton, New Zealand; [5]Ontario Ministry of Environment, Toronto, ON, M9P 3V6; [6]Department of Geography & Environmental Studies, Wilfrid Laurier University, Waterloo, ON, N2L 3C5; [7]Department of Biology, University of Waterloo, Waterloo, ON, N2L 3G1. **Do Stable Isotopes of Nitrate Reveal Source or Processes? Revisiting the Paradigms.**

Stable isotopes of nitrate (δ15N, δ18O) have been used with great success in groundwaters to probe the extent of denitrification and to examine sources of nitrate (NO3-) contamination in aquifers. At the watershed scale, the NO3- stable isotope approach has been extended to identify sources of NO3- to lakes, large rivers, estuaries, the Great Lakes and coastal marine environments. Heightened concern about worldwide N fertilization in combination with the advent of new molecular approaches for microbial ecology has spawned significant advances in our knowledge of N cycling, including new organisms and N-cycling pathways. Concurrently, isotopic analysis of NO3- has become widely available on a routine basis. New emphasis on enzyme based approaches to understanding isotopic fractionations in both marine environments and terrestrial soils has lead to new insights on N cycling, especially on the importance of NO2-. We re-examine paradigms associated with isotopic fractionation and the widely used "Kendall" plot for NO3- sources. Stable isotopic data of NO3- from small streams (1st - 4th order) and large rivers in New Zealand and Canada that are either pristine or impacted by agriculture and/or wastewater treatment plants are examined to determine under what conditions NO3- isotopes reflect sources and/or processes *Keywords: Isotope studies, Agriculture, Biogeochemistry, Wastewater, Nutrients.*

SCHMIDT, N.C.[1], SCHOCK, N.T.[1], COOPER, M.J.[2], and UZARSKI, D.G.[1], [1]Institute for Great Lakes Research; Biology Department, Central Michigan University, Mount Pleasant, MI, 48858; [2]Department of Biological Sciences, University of Notre Dame, Notre Dame, IN, 46556. **Influences of Metabolism on Macroinvertebrate Community Structure Across Great Lakes Coastal Wetland Vegetation Zones.**

Macroinvertebrates can be used as a surrogate for ecosystem health in Great Lakes coastal wetlands, but relationships between invertebrate community composition and emer-

gent vegetation zones must be understood. Vegetation zones can differ in substrate, as well as exposure to wave energy and drainage outlets, so it is likely that zones differ in metabolism rates. We hypothesized that the relative abundances of macroinvertebrate functional feeding groups could be predicted in wetlands by determining the productivity to respiration ratios in each zone. We analyzed invertebrate data collected from Great Lakes coastal wetlands from 2010 to 2013. Collectors and predators were the dominant functional feeding groups in all zones, and the presence of grazers and shredders varied by zone along a gradient from shore to open water. We set up benthic and water-column metabolism chambers in summer 2013 using dissolved oxygen as a surrogate for respiration and gross primary productivity. The most variability among zones was found in the benthos. Zones with sandy substrates tended to have higher P/R ratios. Fetch, depth fluctuations, and the proximity to outlets were also important. We produced a model using parameters that best predicted macroinvertebrate community composition in vegetation zones. *Keywords: Macroinvertebrates, Coastal wetlands, Metabolism.*

SCHMIT, C.L.[1], FARMER, T.M.[1], MARSCHALL, E.A.[1], DABROWSKI, K.[2], and LUDSIN, S.A.[1], [1]Ohio State University, 1314 Kinnear Rd, Columbus, OH, 43212; [2]Ohio State University, 2021 Coffey Rd, Columbus, OH, 43210. **Climate Change Effects on Lake Erie Yellow Perch Spawning Phenology.**

Climate change is altering the timing of seasonal transitions and holds the potential to influence seasonally-specific life-history events such as spawning phenology in temperate fishes. As spawning phenology is directly related to the timing of larval emergence, it may affect the extent to which a 'match' or 'mismatch' occurs between first-feeding larvae and their zooplankton prey during spring. To better understand how the early arrival of spring could affect spawning phenology, we quantified the spawning behavior of Lake Erie yellow perch (*Perca flavescens*) in response to spring temperatures in both field and laboratory settings. In the field, we conducted weekly spring (April-May) sampling in western Lake Erie (2010-2012). In the lab, we conducted controlled experiments with two winter durations (50 and 110 d <5°C) and a single spring warming rate, both representative of recent (1994-2012) Lake Erie water temperatures. Results indicate that yellow perch have the ability to spawn earlier in response to early spring warming but that this response appears limited by other cues that can initiate spawning (e.g., photoperiod). Such limitations may have important implications for the ability of temperate fishes to adequately respond to climate change by influencing overlap of larvae with zooplankton prey. *Keywords: Climate change, Lake Erie, Yellow perch.*

SCHMITT MARQUEZ, H.S.[1], DOLAN, D.M.[1], and CHAPRA, S.C.[2], [1]University of Wisconsin - Green Bay, 2420 Nicolet Drive, Green Bay, WI, 54311; [2]Tufts University, 113 Anderson Hall, Medford, MA, 02155. **Interlake and Total Loading Estimates of Total Phosphorus and Chloride in the Upper Great Lakes System, 1994-2008.**

The Great Lakes Water Quality Agreement (GLWQA) established effluent limits and target loads for phosphorus in the Great Lakes to reduce loading and eutrophication (1972, 1978). The Upper Lakes Reference Group was appointed by the International Joint Commission (IJC) to conduct a comprehensive research study on Lakes Superior and Huron, and submitted an extensive multi-volume report that included interlake transport loads. The current research results, analyzed using data analysis and modeling methods, showed that during 1994 - 2008, Lakes Superior, Huron, and Saginaw Bay exceeded their target loads at least once, while Lake Michigan remained below its target. Updated interlake total phosphorus load estimates showed overall decreasing trends between all lakes, but most notably from Lake Huron to Lake Erie, which steadily declined to 378 MTA in 2008, a decrease of 702 MTA from the load reported by the IJC in 1977 (1,080 MTA). Lake Superior total phosphorus loading to Lake Huron increased by 54 MTA, while Lake Michigan loading to Lake Huron decreased by 8 MTA from 1994 - 2008. Chloride interlake transport showed a 1 MTA decrease in Lake Superior loading, a 64 MTA decrease in the Lake Huron load, and a 243 MTA increase in Lake Michigan loading. *Keywords: Phosphorus, Nutrient loading, Eutrophication, Chloride, Lake model.*

SCHOCK, N.T. and UZARSKI, D.G., 2625 Denison Dr. Lab 123, Mt. Pleasant, Mi, 48858. **Inter-annual variation of habitat conditions and macroinvertebrate communities of a coastal wetland of Saginaw Bay over a 15 year period., MI. 57th International Conference on Great Lakes Research, Hamilton, Ontario.**

Great Lakes coastal wetlands are highly productive and biologically diverse habitats that are vitally important to the health of the Great Lakes ecosystem. Previous research has shown that variation in the dominant vegetation structure within coastal wetland habitats maintain unique habitat conditions and macroinvertebrate communities. We collected chemical-physical habitat data along with macroinvertebrate community data from a coastal wetland, located along the southernmost region of Saginaw Bay Lake Huron from 1999 to 2013. We visited this site eight times over the fifteen year period in order to observe the inter-annual variation of habitat conditions and macroinvertebrate communities at this site. Macroinvertebrate community data was analyzed using non-metric multidimensional scaling (NMDS) in order to condense community data into three dimensions. A mulit-response permutation procedure (MRPP) was then used to determine whether the observed variation was a result of natural variability or if annual changes within macroinvertebrate communities were occurring. Principal components analysis (PCA) was used to detect variation in the habitat conditions among years. These data will help researchers refine tools associated with coastal wetland habitat quality assessment. *Keywords: Coastal wetlands, Saginaw Bay, Bioindicators, Macroinvertebrates, Assessments, Habitat Assessment.*

SCHOEN, L.S.[1], STUDENT, J.J.[1], SIERSZEN, M.E.[2], HOFFMAN, J.C.[2], and UZARSKI, D.G.[1], [1]Central Michigan University, Mount Pleasant, MI; [2]US EPA Mid-Continent Ecology Division, Duluth, MN. **Analysis of Fish Movements Between Great Lakes Coastal Wetlands and Near Shore Habitat via Otolith Microchemistry.**

Great Lakes coastal wetlands are unique habitats often with physical connections to near shore habitat which facilitates the exchange of energy between habitats known as habitat coupling. Coupling can be facilitated by movements of consumers; however, wetland use by fish is largely understudied in the Great Lakes. As a result, our goal was to quantify fish movements between the two habitats. To accomplish this goal, wetland (WL) and near shore (NS) water samples and fish were collected from across the basin for elemental analysis. After standardizing to moles calcium, water samples indicated that Sr and Ba were most important in discerning WL and NS chemistry. Moreover, concentrations of these elements in recently deposited outer-otolith region showed positive relationships with the water chemistry fish were caught in. As a result, outer-otolith Sr:Ca and Ba:Ca from WL and NS caught fish was used to build a predictive model of WL/NS chemistry using linear discriminant function analysis (LDFA). After verifying the model, it was applied to transect data to estimate habitat use. The results indicate distinct life histories for yellow perch including (1) WL/NS residents and 2) fish utilizing WL once/year. These data suggest complex life histories that may facilitate WL-NS coupling. *Keywords: Biogeochemistry, Fish tagging, Wetlands.*

SCHWALB, A.N.[1], BOUFFARD, D.[2], BEOGMAN, L.[2], LEON, L.[3], WINTER, J.G.[4], MOLOT, L.A.[5], and SMITH, R.E.H.[1], [1]Biology Dept., University of Waterloo, Waterloo, ON, N2L 3G1; [2]Dept. Civil Eng., Queens University, Kingston, ON; [3]NWRI, Environment Canada, Burlington, ON; [4]Environ. Mon. Rep. Branch, Ontario Ministry of the Environment, Toronto, ON; [5]Faculty Environ. Studies, York University, Toronto, ON. **Hydrodynamic Controls on Dreissenid Mussel Energetics and Impacts: Insights from 3D Modelling in Lake Simcoe..**

Dreissenid mussels have great potential to redirect energy and material flow in lakes, but physical processes may limit their feeding rates and degree of impact on the lake. A 3 D model of hydrodynamics and ecological processes (ELCOM-CAEDYM) was used to investigate how benthic boundary layer phenomena and physical energy inputs may affect mussel feeding, growth, excretion, egestion, and impact on phytoplankton in Lake Simcoe. The model predicted, and field observations confirmed, that mussels would commonly deplete phytoplankton concentrations near the bottom while elevating the phosphate concentrations. Mussel ingestion and growth were predicted to be strongly limited, consistent with observations in comparable systems and limiting potential for further population increase. Increased inputs of physical energy, in the form of increased storm intensity, were predicted to increase mussel ingestion, growth and the excretion and egestion of P. Despite increased grazing by mussels, phytoplankton biomass was mostly unchanged or even increased by enhanced storms, due to offsetting improvements in nutrient supply and growth. The results highlight the need for a good knowledge of how winds, as well as temperatures, may change in future climate scenarios. *Keywords: Model studies, Zebra mussels, Hydrodynamics.*

SCOFIELD, A.E.[1], WATKINS, J.M.[1], WEIDEL, B.C.[2], ATKINSON, J.F.[3], GHANEEIZAD, S.[3], JOHENGEN, T.H.[4], MILLER, R.[4], and RUDSTAM, L.G.[4], [1]Cornell Biological Field Station, Department of Natural Resources, Cornell University, 900 Shackelton Pt. Rd., Bridgeport, NY, 14850; [2]U.S. Geological Survey, Great Lakes Science Center, Lake Ontario Biological Station, 17 Lake St., Oswego, NY, 13126; [3]Department of Civil Engineering, State University of New York at Buffalo, Buffalo, NY, 14260; [4]School of Natural Resources & Environment, University of Michigan, Ann Arbor, MI, 48109. **Distribution of the Deep Chlorophyll Layer (DCL) in Lake Ontario during 2013: a Vertically Restructured System.**

Greater water clarity in Lake Ontario has led to a vertical redistribution of phytoplankton and increased formation of the deep chlorophyll layer (DCL). Understanding the mechanisms driving DCL formation is a critical step toward predicting its ecological significance. We measured chlorophyll-a concentrations using both in situ and extractive methods to map the distribution of the DCL from April through September 2013, with targeted sampling using an AUV glider in August. During thermal stratification, a strong DCL developed offshore and was closely associated with thermocline depth, as well as with subsurface maxima in dissolved oxygen and particle concentration. These results suggest that the DCL may be an important productivity and biomass feature. In addition, we used a fast-response spectrofluorimetric probe to investigate the vertical structure of phytoplankton communities.

Results indicate that phytoplankton composition often differs between the epilimnion and DCL, with diatoms typically dominating DCL communities and a peak in cryptophyta relative to green algae at depth. The shift in primary production from epilimnetic waters to the metalimnion, along with changes in the ratios of algal classes present, may have important implications for the bioenergetics of zooplankton, mysids and native fish in Lake Ontario. *Keywords: Lake Ontario, Productivity, Phytoplankton.*

SEKOVSKI, D.N.[1], DODEVA, S.L.[2], KODZOMAN, A.K.[1], ZDRAVESKI, N.N.[1], and WATZIN, M.C.[3], [1]United Nations Development Programme, 8 Udarna brigada 2, Skopje, 1000, Macedonia; [2]Swiss Agency for Development and Cooperation, Maksim Gorki 19, Skopje, 1000, Macedonia; [3]College of Natural Resources, North Carolina State University, Raleigh, NC, 27695-8001. **Restoring Lake Prespa: Challenges, Strategy and Results.**

In southeastern Europe, the Prespa Lake ecosystem, a transboundary and globally significant resource, is under pressure from the combined influences of global change and human activities. The continuous load of nutrients and organic matter from agricultural runoff, watershed erosion, wastewater and solid waste is intensifying eutrophication. The conversion of natural landscape elements such as riparian corridors and wetlands is also dramatically reducing the watershed's resilience to these growing pressures. Despite its importance, Lake Prespa is among the least studied freshwater ecosystems, inhibiting the development of more informed management responses. Recently, the Swiss Agency for Development and Cooperation and the UN Development Programme initiated a comprehensive watershed-scale restoration project that includes targeted studies of watershed hydrology, wetland characteristics, land use and water quality. Data synthesis and scenarios assessment will be conducted using coupled lake and watershed models, and a participatory approach will be used to identify and target the most important sources of nutrients and create positive change. The comprehensive restoration approach developed for the Prespa Lake ecosystem will be discussed along with lessons learned and the environmental and socio-economic benefits anticipated. *Keywords: Management, Restoration, Eutrophication, Prespa, Watersheds.*

SERVEISS, V.[1], ARVAI, A.[2], and JARJOUR, J.[3], [1]IJC, Washington Section, 2000 L Street, NW, Washington, DC, 20440; [2]IJC, Great Lakes Regional Office, 100 Ouellette Ave, Windsor, ON, N9A 6T3; [3]IJC, Ottawa Section, 234 Laurier Ave. W, Ottawa, ON, K1P 6K6. **Program Effectiveness Indicators to Assess Progress under the Great Lakes Water Quality Agreement.**

The International Joint Commission (Commission) is an international organization that assists the United States and Canada in the protection of transboundary waters, including the Great Lakes. Under the 2012 Great Lakes Water Quality Agreement (Agreement), one of the Commission's responsibilities is to assess the progress that the governments are making toward achieving the objectives of the Agreement. Two sets of scientific indicators - ecosystem and human health indicators have been developed to monitor progress and demonstrate trends. A third set of indicators called Program Effectiveness Indicators are needed to characterize the extent to which government actions and programs, along with the activity of others, are achieving the Agreement objectives. To assist the Commission in selecting a small set of these indicators, a workshop was convened to acquire consensus-based input from U.S. and Canadian experts. The workshop tasked participants with evaluating and ranking program effectiveness -type indicators in use by government programs and to identify new indicators. Through the workshop a list of top ranked indicators was identified, that can be used by the Commission to fulfill part of its assessment of progress responsibility under the Agreement. *Keywords: Great Lakes basin, Indicators, Management.*

SHAKER, S., DÜRR, H., and VAN CAPPELLEN, P., University of Waterloo, 22 Wycliffe Pl., Kitchener, ON, N2M 5J7. **Reconstruction of Phosphorus Loadings in the Grand River Basin.**

Phosphorus (P) is an important and often limiting nutrient in freshwater systems. Excess P from intense fertilizer use and wastewater inputs can lead to eutrophication, followed by anoxic conditions and harmful algal blooms in rivers and lakes. The Grand River watershed, a 7000 km2 basin in S. Ontario, has undergone major changes in anthropogenic activity and natural changes over the last decades, with ongoing rapid urbanization in the central parts of the basin. Diffuse nutrient sources from intense agriculture and point sources, mostly from wastewater treatment plants (WWTPs) have led to degraded water quality in the central and lower watershed regions. Here we reconstruct past changes in P loadings in the watershed based on long-term historical data on nutrients, discharge, land use, climate, WWTP construction and, population growth. P loads were high prior to the early 1970's and declined in the 1970's and the 1980's. They were more stable in the 1980's and 1990's and increased in the 2000's. We discuss potential control factors such as the phosphorus ban in detergents in the 1970's, reduced chemical fertilizer application after 1980, WWTP upgrades, increases in livestock numbers since the 2000's, population growth and climate trends. *Keywords: Grand River, Phosphorus, Nutrients.*

SHAPIRO, H.[1] and BOEHME, J.R.[2], [1]Public Health Ontario, 480 University Avenue, Suite 300, Toronto, ON, M5G 1V2; [2]IJC Great Lakes Regional Office, 100 Ouellette Ave., 8th Floor, Windsor, ON, N9A 6T3. **Recreational Water Indicators of Human Health Risk in the Great Lakes.**

The Health Professionals Advisory Board (HPAB) of the International Joint Commission has identified two candidate apex indicators linking human health risk to recreational water hazards in the Great Lakes. The development process and measures will be presented for 1) the Risk of Illness from Great Lakes Beaches and 2) Sources of Risk at Great Lakes Beaches. Recreational surface waters and beach sands may harbor microorganisms capable of causing illness in beach visitors, which can result in a significant burden of disease and economic loss. Measurement of the numbers of E. coli (most probable number / colony-forming units of E. coli per 100 ml) at Great Lakes beaches is recommended as a means to assess the Risk of Illness from Great Lakes Beaches. The Sources of Risk at Great Lakes Beaches can be assessed using 1) the main pollution sources identified at beaches that employ a Beach Sanitary Survey or Environmental Health and Safety Survey, and 2) the percentage of beaches employing a Beach Sanitary Survey or Environmental Health and Safety Survey in a given year. Measuring both microbiologic quality of recreational water and sources of nearby pollution for each beach allows for sustainable assessment of overall beach quality. *Keywords: Human health, Beaches, Indicators, Littoral zone.*

SHEN, L.[1], JOBST, K.[2], REINER, E.J.[2], HELM, P.[2], TAGUCHI, V.[2], MCCRINDLE, R.[3], MARVIN, C.[4], BACKUS, S.M.[4], and BRINDLE, I.[1], [1]Brock University, St. Catharines, ON, L2S 3A1; [2]Ontario Ministry of the Environment, Toronto, ON, M9P 3R7; [3]Wellington Laboratories, Guelph, ON, N1G 3M5; [4]Environment Canada, Burlington, ON, L7R 4A6. **Identification, Occurrence and Bioaccumulation of Analogues of Dechlorane 604 Lake Ontario Sediment and Trout.**

Dechlorane flame retardants, containing chlorine and bromine constituents, have been manufactured in the Niagara River area of the Great Lakes, and are found within sediments and biota in the region. These include Dechlorane Plus (DP), which replaced Mirex (aka Dechlorane) as a flame retardant, and Dechlorane (Dec) 602 and 604. We previously reported that Mirex and Dec602 have greater bioaccumulation potentials than Dec 604 and DP based on calculated biota-sediment accumulation factors (BSAFs). This presentation highlights new findings of analogues of Dec604, which contains both bromine and chlorine. Forms with fewer bromines and mixes of bromine and chlorine were identified in Lake Ontario sediment and fish using ultra-high resolution mass spectrometric techniques. The tribromo-Dec604 analogue was present in lake trout at concentrations 50-200 times greater than the 5-50 pg/g ww measured for Dec 604. MonoBr-Dec604 and diBr-Dec604 analogues were also present. Solutions of Dec604 exposed to UV-light indicated that photo-debromination occurs and gives rise to the compounds found in sediment and fish. The triBr-Dec604 analogue, also known as Dec604 Compound B, was more bioaccumulative than Dec604, Dec602 and DP based on BSAFs. The results highlight the need to consider degradation products in the assessment of PBT compounds. *Keywords: Bioaccumulation, Flame retardants, GC/HRMS.*

SHERRY, J.[1], NEHELI, T.[1], CRUMP, D.[2], and KENNEDY, S.[2], [1]Environment Canada, 867 Lakeshore Rd., Burlington, ON, L7R 4A6; [2]Environment Canada, 1125 Colonel By Drive, Ottawa, ON, K1S 5B6. **Differential Gene Expression in Rainbow Trout (Oncorhynchus mykiss) Exposed to Randle Reef Sediment.**

Hamilton Harbour was designated an Area of Concern (AOC) in 1985. There is an ongoing Remedial Action Plan (RAP) to restore the harbour's beneficial uses. Sediment in the Randle Reef (RR) area of Hamilton Harbour is highly contaminated with polycyclic aromatic hydrocarbons (PAHs) and heavy metals. We used differential display PCR (DD-PCR) to develop a molecular fingerprint in juvenile rainbow trout that were exposed to RR sediment. DD-PCR enabled us to identify 42 unique genes that were differentially expressed in livers of fish exposed in the laboratory to RR sediment compared to fish exposed to Lake Ontario water. A 20-gene subset, all of which were confirmed by qPCR, was selected as a response pattern for diagnosing exposure to RR contaminants. CYP1A and Vtg both of which are known to change expression upon exposure to PAHs were up-regulated by exposure to RR sediment. Pathways analysis showed that exposure to RR sediment altered the expression of genes within multiple categories: cell adhesion, cell morphogenesis, DNA synthesis, and immune response. We also explored links between the modulated transcripts and potential health effects. We propose the diagnostic response pattern for use in tracking the efficacy and progress of the proposed remediation of RR from the perspective of fish in the adjacent waters. *Keywords: Hamilton Harbour, Genomics, Fish, Environmental effects.*

SHIMODA, Y.[1], WATSON, S.B.[2], and ARHONDITSIS, G.B.[1], [1]University of Toronto, Ecological Modelling Laboratory, Toronto, ON, M1C 1A4; [2]Environment Canada, Burlington, ON. **Effects of P Loading Reductions and Dreissenid Mussels on the Phytoplankton of the Bay of Quinte, Lake Ontario.**

The Bay of Quinte, a Z-shaped embayment at the northeastern end of Lake Ontario, has a long history of eutrophication problems primarily manifested as spatially extensive algal blooms and predominance of toxic cyanobacteria. The purpose of this work was to identify the apparent effects on the phytoplankton community of two environmental alterations: a point-source phosphorus loading reduction in the late 1970s and the establishment of invading dreissenid mussels about 1995. We first used time-series analysis (X-11, Census II method) along with principal component analysis to define the different types of total phytoplankton and species-specific behavior over the annual cycle and to detect the underlying mechanisms behind those patterns. Our analysis suggests statistically significant differences among communities representing pre- and post P control and pre- and post Dreissena conditions. The shifts in phytoplankton community composition between the identified time periods were attributed to several different taxa, whose relative contributions to the inter-community dissimilarities differed in space. We also used Bayesian inference to predict the likelihood of exceedance of critical microcystin levels. We found that total phosphorous alone is not sufficient to quantify the probability of toxin production in the system. *Keywords: Bay of Quinte, Risk assessment, Harmful algal blooms, Bayesian analysis, Cyanophyta, Eutrophication.*

SHORT, S.M., MIRZA, S., ROZON, R.M., SHORT, C.M., and STANIEWSKI, M.A., University of Toronto Mississauga, Department of Biology, Mississauga, ON, L5L 1C6. **The Ecology of Freshwater Phytoplankton Viruses: Complex Dynamics and New Players.**

Our studies of freshwater phytoplankton viruses have led to many interesting discoveries. Monitoring the abundances of numerous virus genes in a Lake Ontario embayment revealed complex patterns including seasonally stable or sporadic viruses, and geographical patchiness. Even for closely related viruses, distinct seasonality and distribution patterns were observed. Estimates of virus-mediated mortality derived from modified dilution assays suggest that these experiments do not provide absolute estimates of mortality. Rather, since some experiments demonstrated that virus activity could stimulate phytoplankton growth, the method provides estimates of 'viral effects' that are the sum of both mortality and growth stimulation. Finally, given the prevalence of the freshwater prymnesiophyte *Chrysochromulina parva* in Ontario freshwaters, and observations of virus genes in these same environments that were closely related to genes from viruses that infect the marine prymnesiophyte *C. brevifilum*, water samples were screened for lytic activity against *C. parva*. This led to the isolation of a new virus with morphological features and gene sequences demonstrating that it is a member of the *Phycodnaviridae*. The genetic relationship between some prymnesioviruses suggests that they have co-evolved with their hosts. *Keywords: Microbial ecology, Microbiological studies, Viruses, Phytoplankton, Bay of Quinte, Molecular biology.*

SHUCHMAN, R.A.[1], SAYERS, M.[1], LESHKEVICH, G.[2], and FAHNENSTIEL, G.L.[1], [1]Michigan Tech Research Institute, 3600 Green Ct., Ste. 100, Ann Arbor, MI, 48105; [2]NOAA / GLERL, 4840 S. State Rd., Ann Arbor, MI, 48108. **A Satellite Algorithm Tool Box for the Great Lakes.**

A set of operational optical satellite algorithms for the Great Lakes have been developed and successfully tested. These algorithms which utilize CZCS, SeaWiFS, MODIS, MERIS, or VIIRS satellite data generate the following derived products: chlorophyll (chl), dissolved organic carbon (doc), and suspended mineral (sm) concentrations; harmful algal blooms (habs) locations; lake bottom type and bathymetry; sediment plume extent, constituents, and concentration (load); primary productivity (pp); and optical water properties (clarity, Kd, Photosynthetically Active Radiation (PAR) and photic depth). The derived satellite products have been compared to near coincident in situ measurements with good agreement. Time series chl, habs, pp, and optical water properties maps of the five Great Lakes have been generated. In the case of chl, pp, and kd the time series covers the time period of 1979-1987, and 1998 to the present. These time machine looks can be used to better understand the effects climate change, anthropogenic forcing and invasive species have on the Great Lakes. *Keywords: Remote sensing, Optics, Great Lakes basin, Phytoplankton.*

SIERACKI, J.L.[1], BOSSENBROEK, J.M.[1], and CHADDERTON, W.L.[2], [1]Lake Erie Center, 6200 Bayshore Rd., Oregon, OH, 43616; [2]The Nature Conservancy, South Bend, IN, 46617. **Predicting the Spread of Invasive Species via Ballast Water in the Laurentian Great Lakes.**

We built a dynamic spatial model to predict the spread of invasive species due to ballast water discharge in the Great Lakes by fitting it to the past spread of Eurasian ruffe and zebra mussel. For both ruffe and zebra mussel, a model that included trip information between ballast water source and discharge locations and a probability of infestation most accurately backcast past spread. A spread distance that is most likely to occur after each species is discharged was also identified. Backcasting results for Eurasian ruffe let to the selection of two combinations of post-discharge spread and infestation probabilities that best captured past spread (overall accuracies = 0.70 and 0.72). On the other hand, a 20-km post-discharge spread distance and infestation probability of 0.75 (overall accuracy = 0.73) best identified zebra mussel spread. The results of Eurasian ruffe backcasting were used to predict the next most likely locations to become invaded in the Great Lakes. Zebra mussel backcasting results were used to predict the future spread of golden mussel (Limnoperna fortunei) and killer shrimp (Dikerogammarus villosus) if they invade the Great Lakes in the future. *Keywords: Invasive species, Model testing, GIS.*

SIERSMA, H.M.H.[1], QIAN, S.S.[2], and KASHIAN, D.R.[1], [1]Department of Biological Sciences, Wayne State University, Detroit,, MI, 48202; [2]Department of Environmental Sciences, The University of Toledo, Toledo, OH, 43606. **Trends in the Sediment Composition of Saginaw Bay, Lake Huron, 1956-2012: Implications for *Hexagenia* spp. Recovery?**

Multiple anthropogenic disturbances to the Laurentian Great Lakes have had detrimental effects on benthic habitats and biota including decimation of the environmentally sensitive burrowing mayfly genus, *Hexagenia*, from Saginaw Bay, Lake Huron c1960. Because *Hexagenia* similarly declined in western Lake Erie but later recovered, we surveyed Saginaw Bay in 2012 to assess its mayfly recovery status. From Ponar grab samples collected at 48 sites, we found 1.5 nymphs/$m^2$ and nymphal presence at 15.8% of sites sampled, the greatest documented bay nymph distribution since 1956. We also related sampling site abiotic conditions to nymphal presence using Zero-Inflated Poisson regression. Model results indicate the probability of observed nymphal absence being true absence is positively related to both dissolved oxygen concentration and sediment sandiness. Finally, we mapped bay sediment composition based on sampling site texture analyses and made comparisons to prior mapping results. While about half of the bay had sediment with >50% sand content c1975, in 2012 sand levels that high occurred in >75% of the bay with ~66% of sites containing >90% sand. Modeling results coupled with observed changes in bay sediment composition suggest increased sandiness may limit potential *Hexagenia* recovery in Saginaw Bay. *Keywords: Spatial distribution, Hexagenia, Sediments, Saginaw Bay, Habitats, Recovery.*

SIMONS, J.M., Representing: SE Michigan RC&D Council, 22156 Deerfield Trail, Mattawan, MI, 49071. **The Value of Partnerships: Innovation in Monitoring for and Responding to Invasive Species.**

The impact of invasive species outbreaks crosses ecological, social, political, economic, and geographic boundaries. The responsibility for and implementation of scientifically-based monitoring activities and response strategies should also reflect this diversity. In a time of funding scarcity, staffing shortages, and an abundance of emerging and established ecological threats, the fight against aquatic invasive species needs to include all available resources. Many lessons can be learned from innovative partnerships among academic, governmental, non-profit, public, and private organizations. The presentation will provide an overview of successful case studies (with particular emphasis on responses to invasive forest pests, such as the emerald ash borer) to showcase how unconventional partnerships can multiply the reach of existing grant funds and engage more public participation in invasive species management. *Keywords: Invasive species, Public participation, Conservation.*

SINE, S.S.[1], SCHIFF, S.L.[1], SPOELSTRA, J.[1,2], ELGOOD, R.J.[1], CUMMINGS, F.[1], and MOHAMED, M.[3], [1]University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L 3G1; [2]Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6; [3]Ministry of the Environment, 125 Resources Road, Etobicoke, ON, M9P 3V6. **Does δ15N-NO3- reflect land-use in small agricultural catchments?**

Application of synthetic fertilizers and manure production in intensive agricultural areas contributes large quantities of nitrogen (nitrate ($NO_3$), ammonium ($NH_4$)) to the landscape, a proportion of which is lost to surrounding streams. Elevated levels of $NO_3$ and $NH_4$ jeopardize the health of aquatic ecosystems and can result in problems for drinking water treatment. In this study, 22 small catchments in Southern Ontario were sampled in the spring, summer and fall to assess the impact of agricultural land use (crop type, animal population, tile drainage, fertilizer use) on surface water quality. Samples were collected at baseflow for analysis of $NO_3$, $NO_2$, $NH_4$, dissolved oxygen (DO), total phosphorous (TP), Soluble Reactive Phosphorus (SRP), artificial sweeteners, greenhouse gases: carbon dioxide ($CO_2$), methane ($CH_4$) and nitrous oxide ($N_2O$), and $^{18}O/^{16}O$- and $^{15}N/^{14}N$ in $NO_3$. We examine whether nitrogen isotope analysis can be used to provide insight into sources and nitrogen cycling in different seasons. *Keywords: Agricultural watersheds, Nutrients, Stable isotopes.*

SINGH, A. and MURISON, L., Credit Valley Conservation Authority, 1255 Old Derry Road, Mississauga, On, L5N 6R4. **Importance of Real-time Water Quality technology for bridging gaps of traditional water quality monitoring used to calibrate watershed models.**

A practical way of simulating pollutant loadings to the Great Lakes is by developing watershed models. The models are calibrated using monitored data, which are traditionally collected by taking grab samples and/or composite event samples. These monitoring methods provide reasonable water quality information; however, often miss or dampen peak events, which are important for pollutant load estimation. Further, parameters like nutrients and chloride are seasonal based upon their application and are often not very well captured by traditional monitoring methods. Real-time water quality monitoring uses new sonde technology that enables to continuously monitoring some key water quality parameters. These parameters are either used directly in models or are used as surrogates for some of the key Great Lakes water quality parameters of concern. This presentation focuses on five parameters (water temperature, chloride, conductivity, turbidity, and flow) that were recorded at multiple sites in the Credit River, Cooksville Creek, and Sheridan Creek watersheds. The temperature and chlorides drive density of in-stream waters; conductivity reflects influence of urbanization; turbidity is used to estimate total suspended solids and total phosphorus; and flows are used for estimating loadings. *Keywords: Water quality, Monitoring, Pollution load.*

SLAWECKI, T.A.D.[1], SMITH, J.P.[2], GRONEWOLD, A.D.[3], WANG, G.[4], PAIGE, K.[5], and RUCINSKI, D.K.[1], [1]LimnoTech, 501 Avis Dr Ste 1, Ann Arbor, MI, 48108; [2]Cooperative Institute for Limnology and Ecosystems Research, 440 Church Street, Ann Arbor, MI, 48109; [3]NOAA GLERL, 4840 S. State Rd., Ann Arbor, MI, 48108; [4]Great Lakes Commission, 2805 S. Industrial Hwy Suite 100, Ann Arbor, MI, 48104; [5]Great Lakes Observing System, 229 Nickels Arcade, Ann Arbor, MI, 48104. **Web interface to assist with the periodic assessment of withdrawals, consumptive uses, and diversions per the Great Lakes - St. Lawrence River Basin Sustainable Water Resources Agreement.**

The Great Lakes - St. Lawrence River Basin Sustainable Water Resources Agreement was signed by governors and premiers of surrounding states and provinces on December 13, 2005. As a commitment to protect, maintain, and improve the waters and surrounding environment of the Great Lakes and St. Lawrence River Basin, chapter 3 of the agreement focuses primarily on management in the basin. Sections 301 and 302 result from how effective management of any system requires an understanding of the system, which necessitates gathering, dissemination, and analysis of information. A challenge, however, is the reality that information on the Great Lakes and St. Lawrence River Basin is scattered about multiple sources. The Great Lakes - St. Lawrence River Basin Cumulative Impact Assessment Dashboard was developed to aid in the periodic assessment of withdrawals, consumptive uses, and diversions in the basin as prescribed by section 302 of the Agreement. This dashboard taps into data from multiple public and private sector sources, displays the data in multiple formats, and allows for the downloading of raw data for further analysis. Maps and links to the agreement along with supporting organizations are provided for reference. *Key-*

*words: Water level, Cumulative Impact Assessment, Water distribution, Visualization, Data storage and retrieval.*

SMITH, A.K.[1], POWER, M.[1], and MARTY, J.[2], [1]University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L 3G1; [2]WSP Canada Inc, 2611 Queensview Drive Suite 300, Ottawa, ON, K2B 8K2. **Non-lethal sampling of lake sturgeon for stable isotope analysis: comparing pectoral fin-clip and dorsal muscle tissue for use in trophic studies.**

When used to study the feeding ecology of fish, stable isotope analyses generally require lethal sampling to collect tissue which can be undesirable when studying a species at risk such as lake sturgeon (*Acipenser fulvescens*). We evaluated the feasibility of using pectoral fin clips as an alternative to dorsal muscle tissue. Because lipid content can affect stable isotope ratios we also determined whether lipid extraction and mathematical normalization affected the relationship between fin-clips and muscle tissues. Significant positive relationships were observed between fin-clip and muscle tissue for both δ15N ($r^2$=0.63) and δ13C ($r^2$=0.34). Lipid extraction significantly reduced the among-individual variation, and improved the δ13C relationship significantly ($r^2$=0.76). While mathematical lipid normalization did effectively reduce the among-individual variation, a consistent enrichment relative to chemical extraction was observed. The strong relationships between fin-clip and muscle tissue signatures demonstrate that fin-clips should be considered as good surrogates for muscle tissue, which will allow trophic studies to accurately adjust for the effect of differential lipid accumulation and for lake sturgeon can effectively limit the need for invasive sampling. *Keywords: Stable isotopes, Lake Sturgeon, Tissue Comparison.*

SMITH, D.S., Toronto and Region Conservation Authority, 5 Shoreham Drive, Toronto, ON, M3N 1S4. **City of Toronto Wet Weather Flow Monitoring Network: Baseline Conditions 2008 to 2011.**

The City of Toronto's Wet Weather Flow Master Plan is an initiative to address the impacts of runoff generated by precipitation in order to protect local watercourses, infrastructure, and ultimately Lake Ontario. The plan is designed with a "treatment train" approach to implement stormwater management technologies and retrofits over the next 25 years. In 2007, the City in partnership with the Toronto and Region Conservation Authority constructed an advanced automated monitoring network to document current conditions of the City's major watercourses to be used as a benchmark against which the corresponding effects or benefits of implementing the plans control measures can be compared and quantified. While the project is in its infancy, one of the study goals is to collect water quality and water quantity information under wet weather, dry weather, and snow melt flow regimes using the latest technology and sampling techniques. Presented are selected results of the 2008 to 2011 monitoring period and updates on future initiatives. *Keywords: Water quality, Stormwater, Urban watersheds, Runoff, Pollution load, Precipitation.*

SMITH, J.P.[1], GRONEWOLD, A.D.[2], CLITES, A.H.[2], and HUNTER, T.S.[2], [1]Cooperative Institute For Limnology and Ecosystems Research, 440 Church Street, G110 Dana Building, Ann Arbor, MI, 48109-1041, United States; [2]National Oceanic and Atmospheric Administration - Great Lakes Environmental Research Laboratory, 4840 S. State Rd., Ann Arbor, MI, 48108-9719, United States. **Past, Present, and Future of The Great Lakes Dashboard - A Dynamic Graphical Interface for Visualizing Data Describing Various Aspects of the Laurentian Great Lakes Environment.**

In 2011, development of a Great Lakes regional climate dashboard was proposed. Research and resource management communities needed access to Great Lakes data in a framework allowing for visual analysis of data over many temporal scales and comparisons between model forecasts and observations from different sources. Development began January 2012 at National Oceanic and Atmospheric Administration's Great Lakes Environmental Research Lab, and has accelerated since then. While the public dashboards hold a limited amount of water level, forecast, hydrological, and ice cover data, a new behind-the-scenes dashboard handles more data with capability to add data easily. This talk will review development of the dashboard. The current public dashboards were built under limited scope, uncertain developer availability, uncertain audience acceptance, and no prior experience of the dashboard's programming framework. The future dashboard embraces high level programming concepts for easy and efficient feature expansion. It represents a paradigm shift from a web visualization to a tailored web office application. To cater to both general users and users with managerial or research interests, we propose a dashboard portal with a basic visualization of water levels and water level forecasts, and links to more detailed dashboards. *Keywords: Environmental education, Decision making, Data visualization, Data storage and retrieval.*

SMITH, J.P.[1], RUBERG, S.A.[2], and MUZZI, R.W.[2], [1]Cooperative Institute for Limnology and Ecosystems Research, 440 Church Street, G110 Dana Building, Ann Arbor, MI, 48109-1041; [2]National Oceanic and Atmospheric Administration - Great Lakes Environmental Research Laboratory, 4840 S. State Rd., Ann Arbor, MI, 48109-9719. **Web Presence for the Great Lakes Synthesis, Observations And Response (SOAR) System - A Portal to**

**View Real-time Sensor Data from Buoys in Lake Erie, Lake Michigan, and Saginaw Bay.**

To support the web presence objective of the Great Lakes Restoration Initiative's Synthesis, Observations and Response (SOAR) System, the National Oceanic and Atmospheric Administration's Great Lakes Environmental Research Lab (NOAA-GLERL) developed a prototype dashboard displaying data relevant to ecosystem health, harmful algal blooms and hypoxia. The dashboard provides timely observations to constituents such as Great Lakes water intake managers on the state of the raw water resource to support water treatment decisions. Scientists at NOAA-GLERL observe parameters such as dissolved oxygen, temperature profiles, and surface currents to improve models and ecosystem forecasts. Research efforts are also focused on the formation and movement of toxic HABs and hypoxia to better understand food web implications. The prototype dashboard, along with the graphed data, has a map with overlays of modelled surface currents and MODIS imagery. A new portal displays additional buoy data and map overlays from Lake Erie, Lake Michigan, and Saginaw Bay. We plan to expand data coverage to include real time phosphorous and other optical data such as turbidity and chlorophyll concentration, plus currents and wave heights at buoys. *Keywords: Buoys, Data storage and retrieval, Decision making.*

SMITH, S.D.P.[1], JOHNSON, L.B.[2], ALLAN, D.[1], BRADY, V.[2], BROWN, T.[2], CAI, M.[2], CIBOROWSKI, J.J.H.[3], HOST, G.[2], KOVALENKO, K.E.[2], REAVIE, E.D.[2], and KELLY, J.[4], [1]Univ of Michigan, Ann Arbor, MI, 48109-1041; [2]Univ of Minnesota Duluth, Duluth, MN, 55811; [3]Univ of Windsor, Windsor, ON, N9B 3P4; [4]Mid-Continent Ecology Division, Environmental Protection Agency, Duluth, MN, 55804. **A Comprehensive Stressor-Response Model to Inform Ecosystem Restorations Across the Great Lakes Basin.**

Successful restoration planning and execution requires comprehensive data depicting stress types and sources. Essential needs include identifying reference conditions and causes of impairment to guide restoration targets and indicate success. Two recent projects have characterized human activities across the Laurentian Great Lakes. The Great Lakes Environmental Indicators (GLEI) project mapped and ranked risks of land-derived stressors for each watershed basin-wide; the Great Lakes Environmental Assessment and Mapping (GLEAM) project depicted individual and composite impacts of 34 stressors in 1-km pixels across the lakes. Both datasets identify stress types threatening biota in the basin, but they have not been compared to each other or to contemporary water quality and biological data. We present initial results using spatial frameworks to compare data from the two projects and visualization methods to combine the stressor maps into a single composite map for the basin. We have found positive correlations among indices of stress from both projects. We are continuing to identify and calibrate bioindicators for nearshore and offshore habitats using the datasets. We expect results to inform selecting stressor gradients and biological indicators to enhance restoration and management across the region. *Keywords: Spatial analysis, GIS, Environmental effects.*

SOKOL, E.C., URBAN, N.R., and PERLINGER, J.A., Michigan Technological University, 1400 Townsend Drive, Houghton, MI, 49931, US. **Polychlorinated Biphenyl (PCB) Fish Contamination: A Look at Michigan's Upper Peninsula Inland Lakes.**

Fish consumption advisories based on total Polychlorinated Biphenyl (PCB) concentration are of great concern in the state of Michigan's Upper Peninsula where five lakes exceed the Total Maximum Daily Load (TMDL). The statewide TMDL for PCBs in Michigan is intended to address water bodies impacted by atmospheric deposition while local source contamination is considered separately. Despite its predominantly rural nature, the Upper Peninsula has a history of industrial PCB use. Several factors could contribute to the widely varying PCB concentrations in fish from nearby lakes including local point sources, unique watershed and lake characteristics, and food web structures that affect bioaccumulation. In order to decipher the cause of variable PCB concentrations in neighboring lakes, we have chosen a set of congeners to represent the distribution of PCBs in sampled fish species for the lakes of interest. Congener concentrations and distributions were compared with output from bioaccumulation models to examine the effects of food web structures. The congener distributions in fish were also statistically compared to distinguish lakes impacted by local sources from those impacted only by atmospheric deposition. *Keywords: PCBs, Bioaccumulation, Fish, Pollution sources.*

SORENSEN, H.L.[1] and STEWART, R.M.[2], [1]Minnesota Sea Grant, University of Minnesota Duluth, 31 W. College Street, Duluth, MN, 55812; [2]Lakehead University, 955 Oliver Rd, Thunder Bay, ON, P7B 5E1. **Citizen based monitoring and lakewide management: Recommendations for information sharing and partnership development in the Lake Superior Basin.**

The Lake Superior Basin has a diverse range of stakeholder partnerships and citizen-based monitoring programs focused on ecosystem protection, restoration and management. This research explores how partnerships for environmental citizen-based monitoring may contribute to information sharing and enhance lakewide management in the Lake Superior

Basin. Results were compiled based on a qualitative theme analysis and were used to highlight the strengths and weaknesses of current partnerships in citizen-based monitoring and multi-scale collaborative resource management efforts. Results showed a variety of interest groups and organizations engaged with the incorporation of CBM into their monitoring and restoration activities, however, further collaboration and communication across jurisdictional and geographical boundaries may offer potential benefits in the reduction of duplicated efforts, development of common monitoring methodologies, and availability of information. The role of multi-scale, binational partnerships is of vital importance in implementing an ecosystem approach to the management of Lake Superior and for the Laurentian Great Lakes system and can further development of multi-stakeholder governance efforts of cross-jurisdictional water resources around the world. *Keywords: Monitoring, Partnerships, Ecosystem health, Governance, Lake Superior.*

SPOELSTRA, J.[1,2], SCHIFF, S.L.[2], and BROWN, S.J.[1], [1]Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6; [2]Department of Earth and Environmental Sciences, University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L 3G1. **How sweet it is! High concentrations of artificial sweeteners in the Grand River.**

Artificial sweeteners have been widely incorporated in human food products for aid in weight loss regimes, dental health protection and dietary control of diabetes. Some of these compounds pass non-degraded through wastewater treatment systems and are subsequently discharged to groundwater and surface waters. We analyzed samples from 23 sites along the length of the Grand River in order to determine the concentrations of 4 artificial sweeteners and their usefulness as a tracer of wastewater at the scale of an entire watershed. Municipal water from household taps was also sampled from several cities within the Grand River Watershed. Cyclamate, saccharin, sucralose, and acesulfame were all present in the river and the maximum concentrations measured for sucralose, cyclamate, and saccharin are the highest reported concentrations in surface waters to date anywhere in the world. Acesulfame persists at concentrations that are up to several orders of magnitude above the detection limit over a distance of 300 km, recording the wastewater contribution from the cumulative population in the basin. Acesulfame is a reliable wastewater effluent tracer in rivers and can be used to assess, for example, rates of nutrient assimilation, track wastewater plume dilution, and determine the relative persistence of emerging contaminants. *Keywords: Grand River, Tracers, Great Lakes basin, Sweeteners, Water quality, Wastewater.*

ST. PIERRE, J.I.[1], CIBOROWSKI, J.J.H.[1], AXLER, R.[2], BROWN, T.[2], BRADY, V.[2], DANZ, N.[5], GATHMAN, J.[4], KOVALENKO, K.E.[2], HOST, G.[2], HOWE, R.W.[3], NIEMI, G.J.[2], REAVIE, E.D.[2], and JOHNSON, L.B.[2], [1]University of Windsor, 401 Sunset Ave, Windsor, ON, N9B 3P4; [2]Natural Resources Research Institute, 5013 Trunk Miller Highway, Duluth, MN, 55811; [3]University of Wisconsin, Green Bay, 2420 Nicolet Drive, Green Bay, WI, 54311; [4]University of Wisconsin- River Falls, 410 S. 3rd Street, River Falls, WI, 54022; [5]University of Wisconsin- Superior, Belknap & Catlin P.O. Box. 2000, Superior, WI, 54880. **Characterizing Biotic Response to Cumulative Anthropogenic Stress at Great Lakes Coastal Margins.**

Coastal ecosystems of the Great Lakes provide many ecological services; yet, they are the most highly threatened by anthropogenic stressors. Sustainable use requires balancing the extent and types of activities within the watershed against their impact on ecosystem services. Several measures of Great Lakes cumulative stress have been proposed, and measures of expected impact exist for watersheds across the entire basin. However the degree to which coastal margin biota reflect the expected environmental condition at locations subject to multiple forms of stress is largely unknown. Sites were identified throughout the Great Lakes basin where combined effects of large-scale (watershed level) stress due to agricultural activity and/or urban development were expected to result in a degraded environmental condition. Estimated cumulative risk varied considerably, depending on whether stress effects were considered to be independent (additive), synergistic (multiplicative) or antagonistic (hierarchical). The biological condition of plant, invertebrate, fish, and bird assemblages at these sites was assessed and ordinated to determine how biota perceived the cumulative (combined) effects of the stressor classes. *Keywords: Biomonitoring, Multiple stressors, Coastal ecosystems, Cumulative effects.*

STANFIELD, L.W., Ontario Ministry of Natural Resources, 41 Hatchery Lane, Picton, ON, K0K 2T0. **Quantifying assimilative capacity of all tributaries to Lake Simcoe based on cumulative impacts to biological integrity.**

Landscape models quantified the relationship between land use, climate, fragmentation and background measures of geology, slope, and area with metrics of fish and benthos communities of tributaries to Lake Simcoe. The premise for this study is that healthier food chains are likely contributing lower volumes of phosphorus to Lake Simcoe. Both land use and fragmentation were significant predictors of fish assemblages, although the patterns varied with geology. Site condition was calculated in comparison to a hindcasted reference condition of total forest cover in order to classify segments as impaired, likely impaired and un-

impaired. Comparing stream states to existing phosphorus loads to Lake Simcoe revealed challenges in scaling that have implications for strategic planning. Stream segments are often impacted due to local land use that in some cases are mitigated due to confluences with other unimpacted segments, while in other situations issues are exacerbated. The importance of having a landscape approach that includes "zooming- in" and "zooming-out" capabilities that can view condition over multiple spatial scales was shown to be an essential component of understanding the factors that impact stream conditions due to non-point source impacts. *Keywords: Ecosystem modeling, Cumulative effects, Eutrophication, Watersheds.*

STANIEWSKI, M.A.[1], FITZPATRICK, M.[2], MUNAWAR, M.[2], and SHORT, S.M.[1], [1]Department of Ecology and Evolutionary Biology, University of Toronto, 25 Willcocks Street, Toronto, ON, M5S 3B2; [2]Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries & Oceans Canada, 867 Lakeshore Rd., Burlington, ON, L7R 4A6. **Exploring the Influence of Viruses on Phytoplankton and Bacterial Production in Hamilton Harbour: a Preliminary Assessment.**

Viruses often significantly influence the flow of energy and nutrients in aquatic ecosystems. In addition to their role as agents of mortality, recent findings suggest that the occurrence of viral lysis may enhance primary production for certain uninfected algal taxa (via nutrient recycling, competitor reduction, liberation of organic material, etc.). The purpose of this study was to determine if viral effects (either lytic or stimulatory) could be detected in primary and secondary productivity assays of Hamilton Harbour water samples in order to further our understanding of microbial dynamics in this Area of Concern. Bacterial and size-fractioned primary production experiments involving viral-reduction treatments (dilutions with virus-free ultrafiltrate) were performed in August and November 2013. Picoplankton (<2 µm) and bacterial productivity were significantly decreased in the viral reduction treatments in August, while net (>20 µm) and nanoplankton (2-20 µm) productivity were not. Bacterial productivity was also significantly decreased in the November viral reduction treatments. The results of this study provide empirical evidence for the importance of viruses in potentially mediating bacterial and primary production in the harbour. *Keywords: Hamilton Harbour, Phytoplankton, Productivity.*

STASTNA, M. and STEINMOELLER, D.T., Department of Applied Mathematics, University of Waterloo, 200 University Ave. West, Waterloo, ON, N2L 3G1. **On the generation of short internal waves by lake scale internal seiches.**

In the late summer when the thermocline is found well below the water surface, lake scale internal seiches can interact with the sloping lake bottom over a large geographical area . Many simulations use idealized bottom topography which is smoother than actual lake bottoms, and often adopt the hydrostatic approximation which is relevant for motions with large horizontal length scales. In this talk we will present high resolution numerical simulations of shoaling internal seiches using a scalable, pseudo spectral, non hydrostatic model. The model can handle density overturns and a complex bottom bathymetry. We will illustrate that bottom undulations of moderate amplitude and slope that occur near the region where the thermocline intersects the bottom can lead to the generation of large amplitude, short internal waves. At times these waves are energetic enough to induce local overturns. We will argue that this is an example of an indirect cascade in which motions with long length scales can force wave activity on short length scales without energy first passing over the length scales in between. This suggests that the classical paradigm of the turbulence cascade over the inertial subrange, which is based on homogeneous, isotropic turbulence, needs to be modified for stratified lakes. *Keywords: Hydrodynamics, Waves, Computer models.*

STEFANOFF, S.[1], NEFF, M.R.[2], and BHAVSAR, S.P.[2], [1]York Univeristy, Toronto, ON; [2]Ontario Ministry of the Environment, Toronto, ON. **Improvements in Fish PCB and Other Contaminant Levels in Response to Remedial Actions at Hamilton Harbour, Ontario, Canada.**

Hamilton Harbour, located at the western end of Lake Ontario, Canada is recognized as one the most degraded regions within the Great Lakes and is currently listed as an Area of Concern (AOC). One of the Beneficial Use Impairments (BUI) for the harbour has been restrictions on fish consumption due to elevated contaminant levels. In this study, we examined past and recent fish contaminant data collected by the Ontario Ministry of the Environment (OMOE) in partnership with other agencies to evaluate temporal trends in fish contaminant concentrations. Measurements for both resident and migratory sport fish as well as juvenile/forage fish were considered, with analysis focused on PCBs, the group of chemicals identified as the major contaminant of concern. Current contaminant levels were evaluated against fish consumption advisory benchmarks used by OMOE, and compared with corresponding observations for other locations across the Great Lakes, including other AOCs. The results show improvements in fish contaminant levels within Hamilton Harbour, especially for PCBs; however, recovery of the AOC is still on-going and the BUI concerning fish consumption remains impaired. *Keywords: Fish, PCBs, Pollutants.*

STEINMOELLER, D.T., STASTNA, M., and LAMB, K.G., Dept. of Applied Math, University of Waterloo, 200 University Ave. W., Waterloo, ON, N2L 3G1. **Calculating free modes of oscillation in arbitrarily-shaped closed basins.**

The calculation of free modes of oscillation in closed rotating basins represents a thoroughly-studied problem with previous works dating back well over a century The importance of free modes of oscillation in understanding basin-scale dynamics in large lakes is thus well-known, and a method that can calculate these modes on numerical grids that accurately reflect the actual geometry of real-world lakes is desirable since these numerically calculated modes allow hypotheses regarding the basin-scale dynamics of lakes to be formulated and tested against field data. In this work, we employ an analytical reduction used in previous works to recover a problem in terms of a self-adjoint operator and solve the problem numerically with triangular grids using the symmetric interior penalty discontinuous Galerkin finite element method (hereafter, SIP-DG). The method represents an improvement over previous works since it allows the coastline to be represented in a piece-wise linear manner and allows for accurate calculations by increasing the order of the local approximating polynomials. Our numerical methodology for calculating the free modes of oscillation in rotating basins of arbitrary geometry will be presented followed by validation cases, a case study of an idealized basin, and applications to real-world large lakes. *Keywords: Great Lakes basin, Computer models, Hydrodynamic model.*

STEPHENSON, S.L.[1], CORKUM, L.D.[1], ZHAO, Y.[2], and CIBOROWSKI, J.J.H.[1], [1]University of Windsor, Department of Biological Sciences, Windsor, ON, N9C 3P4; [2]Ontario Ministry of Natural Resources, Lake Erie Fishery Station, Wheatley, ON, N0P 2P0. **Effects of temperature on round goby (Neogobius melanostomus) larval survival, development and distribution.**

The invasive round goby (*Neogobius melanostomus*) detrimentally affects native species in the Great Lakes basin. Furthermore, the larval stage is believed to be pelagic, aiding in the species' dispersal. Temperature is likely the major environmental determinant of larval duration. Understanding temperature-development relationships could assist with management. Round goby eggs were collected in June and July from artificial nests deployed at Erieau, Lake Erie. Newly hatched larvae were reared in aquaria at 15°C, 20°C and 25°C, reflecting water temperatures at Erieau. The rate of yolk sac absorption varied significantly with temperature ($p = 0.009$); larvae reared at 25°C and 20°C completed yolk absorption by days 7 and 9, respectively. In contrast, larvae at 15°C retained their yolks after 30 d. Larval mortality varied significantly with temperature ($p < 0.001$). Higher mortality was observed in larvae reared at 15°C than those at 20°C. A subset of larvae was observed for 24-h periods to document swimming behaviour. Round goby larvae exhibited diel periodicity, with a greater proportion of larvae entering the water column at night. Data will be used to develop a recruitment model for the species. *Keywords: Round goby, Development, Fish behavior, Invasive species.*

STEVENSON, R.J., NOVITSKI, L., and ESSELMAN, P.C., Deprtment of Zoology, Michigan State University, East Lansing, MI, 48824. **Relating Algal Blooms in the Nearshore Zone Determined by Satellite Remote Sensing to Rivers, Nutrient Loading, Watershed Land Use, and Storm Events.**

The overarching goal of our project was to identify watersheds for restoration that will reduce risk of algal blooms in the coastal zones of the Great Lakes. We hypothesized that we could relate algal biomass in the coastal zone of the Great Lakes, nutrient concentrations, watershed land use, and storm events with algal biomass determined using MODIS and Landsat remote sensing images and models of nutrient loads from watersheds based on land use and hydrology. Our models of chlorophyll a based on remote sensing images (RS inferred chl a) and nutrient loading in coastal zones were validated with measured chlorophyll concentrations in the Great Lakes and nutrients in rivers. RS-inferred chl a was related to nutrient loading from rivers, which was dependent upon recent storm events and land use in watersheds. RS-inferred chl a was more related to nutrient loads during the week preceding measurement of chl a than other periods before or during chl measurement. This lag time is presumably related to algal growth following nutrient loading, and was non-linearly related to nutrient loading. Our results indicate that these tools will improve understanding of land use effects on algal blooms in coastal zones of the Great Lakes and will help identify priority watersheds for restoration. *Keywords: Algae, Remote sensing, Nutrients.*

STEWART, T.J.[1], WEIDEL, B.C.[2], WALSH, M.G.[2], and JOHNSON, T.B.[3], [1]Ontario Ministry of Natural Resources, Lake Ontario Management Unit, Picton, ON, K0K 2T0; [2]U.S. Geological Survey, Lake Ontario Biological Station, Oswego, NY, 13126-0000; [3]Ontario Ministry of Natural Resources, Aquatic Research and Development Section, Picton, ON, K0K 2T0. **A "Fish-Head" Perspective On The Lake Ontario 2013 Coordinated Science And Monitoring Initiative.**

The Coordinated Science and Monitoring Initiative (CSMI) is a binational effort under the auspices of the Great Lake Water Quality Agreement. Building on two water-quality focused surveillance programs sponsored by Environmental Protection Agency and Environment Canada participating agencies establish priorities and conduct complementary and integrated multi-trophic level surveillance programs. Here we provide an overview of the development and implementation of the Lake Ontario 2013 CSMI. We highlight lesson learned and discuss advantages and disadvantages from the perspective of fisheries agencies trying to understand and manage fishery resources. We present an alternative fisheries management information model that integrates ecosystem drivers and fisheries and discuss the challenges of its application. *Keywords: Food chains, Fish management, Lake Ontario.*

STILLE, F.B., Toronto and Region Conservation, 5 Shoreham Drive, Downsview, ON, M3N 1S4. **Restoration Planning in an Urban Context - A Multi-Discipline Approach to Prioritization in the Greater Toronto Area.**

Toronto and Region Conservation (TRCA) restores more habitat than any other organization in the GTA, investing millions of dollars every year. TRCA has the responsibility to invest this funding wisely to achieve restoration outcomes that help to realize the requirements of our funding partners, TRCA's objectives, and development compensation options. Effective ecosystem restoration requires an integrated approach, considering many components of the natural system when prioritizing where and what to restore. TRCA has a wealth of knowledge on terrestrial biodiversity, aquatic ecosystems, surface and ground water, and headwater streams. This project aims to consolidate this information into a systematic process that will help direct decision making during restoration planning. Focus is on identifying impairments and threats to ecosystem function as a means to improve the delivery ecological goods and services. It incorporates multiple disciplines into an integrated planning framework that ensures all relevant information on ecosystem function is considered when prioritizing restoration objectives. It formalizes this process into a comprehensive, consistent, defensible and repeatable framework, thereby improving marketability and support for its implementation. The goal is to set a process to be utilized across the Great Lakes. *Keywords: Decision making, Ecosystems, Planning.*

STOLL, J.R., RIETH, A.M., DORNBUSH, M.E., FERMANICH, K.J., and BAUMGART, P.D., UW-Green Bay, MACH B310, 2420 Nicolet Drive, Green Bay, WI, 54311-7001. **Agricultural Land Conversion with an Environmental Purpose: Switchgrass as a Phosphorous Control Method in the Lower Fox River Watershed.**

Northeast Wisconsin's Lower Fox River Watershed(LFRW) is most commonly used for agriculture, contributing high phosphorus and total suspended solid loads to the Bay of

Green Bay. A contentious focus of programs for years, two notable recent actions targeted 1)PCB remediation and 2)development of phosphorous trading. Using watershed and crop enterprise models, we examine three scenarios wherein marginal cropland, defined as low-land areas often subjected to extended periods of water saturation, is converted to switchgrass. Alternative conversion scenarios are: SVP-poorly drained; PVP-very poorly drained; and WQ-SVP that combined SVP drainage with sub-watersheds having the worst phosphorous runoff. We used a 13,900 acre conversion constraint to limit major structural change to regional production patterns. Our initial hypothesis that producers would plant switchgrass, if more profitable than current crops was confirmed by research results. Importantly, our work demonstrates switchgrass profitability improves with a) consideration of broader social goals, and b) utilizing existing subsidy programs. The WQ-SVP scenario targeting phosphorous problem areas provides the most likelihood of crop conversion. Fuller development of pellet markets for switchgrass would improve their potential even further. *Keywords: Economic evaluation, Switchgrass, Water quality, Management, Phosphorus, Externalities.*

STOW, C.A.[1], CHA, Y.[2], and QIAN, S.S.[3], [1]NOAA GLERL, Ann Arbor, MI, 48108; [2]University of Michigan, Ann Arbor, MI; [3]University of Toledo, Dept of Env Sciences, Toledo, OH. **A Bayesian approach to guide development and evaluation of substance objectives under the 2012 Great Lakes Water Quality Agreement.**

Under the 2012 Great Lakes Water Quality Agreement Canada and the United States are obliged to develop target concentrations for water quality constituents of particular concern. These "substance objectives" are closely analogous to numerical criteria under the US Clean Water Act. To develop effective substance objectives it is important to consider how compliance with these objectives will be evaluated. Total phosphorus concentrations, for example, vary temporally and spatially, thus sample-based statistics will always be uncertain measures of the "true" underlying population characteristic. Using data from Saginaw Bay we develop a Bayesian hierarchical model that can be used to evaluate compliance with target concentrations on a temporally and spatially explicit basis. The "confidence of compliance" with targets can be assessed from the variance of the model parameter posterior distributions. This approach allows data to be grouped to represent spatial and temporal domains of particular interest, such as spring mean conditions in a certain area, and facilitates "partial pooling" of information so that regions with sparse data and high uncertainty can "borrow information" more data-rich areas. *Keywords: Water quality, Mathematical models, Monitoring.*

STURTEVANT, R.A.[1], FUSARO, A.J.[2], and RUTHERFORD, E.S.[1], [1]NOAA Great Lakes Sea Grant Network, 4840 South State Road, Ann Arbor, MI, 48108; [2]Wayne State University, Department of Biological Sciences, 5047 Gullen Mall, Detroit, MI, 48202. **GLANSIS - Assessment of the Relative Impact of Established Nonindigenous Species.**

Over 180 nonindigenous species have been reported to have reproducing populations in the Great Lakes basin, i.e. lakes Superior, Michigan, Huron, St. Clair, Erie, Ontario, and their connecting channels and water bodies within their respective drainages (Mills et al. 1993, Ricciardi 2001, Ricciardi 2006, Ricciardi unpubl. data). The Great Lakes Restoration Initiative (GLRI) funded NOAA to expand information on the impact of these species within its Great Lakes Aquatic Nonindigenous Species Information System (GLANSIS) to support management decision-making. Our impact assessment tool evaluates environmental, socioeconomic and beneficial impacts of these species in a consistent, quantitative manner allowing comparisons across taxa. All 180 species included in the database have been assessed. We present the rankings of high impact species as well as a summary of key cross-taxa trends and an analysis of information needs. *Keywords: Invasive species, Assessments, Great Lakes Restoration Initiative (GLRI).*

SU, G.[1], LETCHER, R.J.[1], GREAVES, A.K.[2], and GAUTHIER, L.T.[1], [1]Environment Canada, National Wildlife Research Centre, Carleton University, Ottawa, ON, K1A 0H3; [2]Department of Chemistry, Carleton University, Ottawa, ON, K1S 5B6. **Determination of organophosphate flame retardants metabolites in three polarity-specific animal issues by use of liquid chromatography-tandem quadrupole mass spectrometry.**

The usage of organophosphate flame retardants (OPFRs) has increased due to the phase-out of lower brominated polybrominated diphenyl ether (PBDE) FRs. Environmental detection of OPFRs had become more frequent in recent years. For example, tris(1,3-dichloro-2-propyl) phosphate (TDCIPP) and triphenyl phosphate (TPHP) were detected in 96% and 98% of house dust sample at higher concentrations than those of PBDEs, and total atmospheric OPFR concentrations were found up to 2100±400 pg/m3 at some sites in the North American Great Lakes basin. However, OPFR concentrations in limited wildlife tissue and egg studies from the same region were much lower than anticipated. This indicates that OPFRs may undergo rapid metabolism after entering the body. To verify this hypothesis, methods need to be developed to analyze OPFR metabolites in various biological tissues. We presently report on the development and application of an analytical method for the determination of sixteen OPFRs and six OPFR metabolites by LC-ESI-MS. The method validation included three polarity-specific biological tissues: serum (high polarity), chick eggs

(mid polarity) and pork liver (low polarity). Finally, the applicability of this method was confirmed by analyzing OPFR metabolites in plasma samples from herring gulls from Lake Huron and collected in 2010. *Keywords: Chemical analysis, Organophosphate flame retardants metabolites, LC-ESI-MS, Polarity-specific matrices.*

SUMMACH, D.T.[1], FAUSTO, J.A.[1], ROBICHAUD, D.[1], BICUDO, J.[2], and CELMER-REPIN, D.[3], [1]LGL Limited, Cambridge, ON; [2]Associated Engineering (With Region of Waterloo 2007-2013), Kitchener, ON; [3]Region of Waterloo, Kitchener, ON. **Long Term Monitoring of Water Quality in the Vicinity of Wastewater Treatment Plants in the Region of Waterloo - Water Quality Observations in the Grand River Watershed During Summer Low Flow Events.**

The Regional Municipality of Waterloo initiated a Surface Water Quality Monitoring Program in the Grand River Watershed in 2007 in response to planned upgrades to wastewater treatment plants (WWTPs) discharging to rivers in the watershed. With the unusually low river flows experienced in recent years, the river's response to WWTP discharges in warm and dry weather is a topic of concern to the regulators, watershed managers, as well as WWTP operators due to reduced assimilative capacity under these conditions. A comparison of trends in water quality data will include results from water chemistry analysis, as well as the presence and extent of wastewater plumes at each WWTP outfall to characterize effluent effects within a receiving water body. The presentation will highlight the summer data and will compare results on a statistical basis. Two non-parametric statistical analyses were employed for this study, the Kruskal-Wallis and Mann-Whitney tests. For many parameters, such as phosphorus, concentrations are significantly higher in dry years vs normal to wet years, while other parameters such as nitrates, are significantly lower in dry years. The challenges associated with wastewater discharges during low flow conditions are discussed and the immediate changes that have been observed as WWTPs are upgraded are illustrated. *Keywords: Grand River, Water quality, Monitoring.*

SUN, F.[1], PONNAMBALAM, K.[1], SHENG, D.[2], and PAGSUYOIN, S.[3], [1]Department of Systems Design Engineering, University of Waterloo, Waterloo, ON, N2L3G1; [2]No. 370, Shaoshan North, Dongtang, Hunan Water Resources and Hydropower Research Inst., Changsha, HU, China; [3]Department of Civil and Environmental Engineering, University of Waterloo, Waterloo, On, N2L 3G1, Canada. **Chlorophyll-a Modeling with Support Vector Regression in Taihu Lake of China, 1998-2006.**

Chlorophyll-a is a fundamental measure of eutrophication in lakes. In this study, support vector regression (SVR) was applied to describe the relation between Chlorophyll-a and other environmental factors, based on the 1998-2005 field measured data from Taihu Lake, China. And the real observation of 2006 was used for model validation. Since support vector machines have great generalization ability and guarantee global minima for given training data, it is believed that SVR will perform well. Compared to the real observation, the model performance was evaluated by means of the squared correlation coefficient R2 and the Root Mean Square Error (RMSE). The results suggest that SVR can can be used the prediction of Chlorophyll-a. *Keywords: Model studies, Nutrients, Monitoring.*

SWANSON, H.K.[1], KRUEGER, C.C.[2], BRONTE, C.R.[3], MUIR, A.M.[2], LOSETO, L.L.[4], SITAR, S.P.[5], and HANSEN, M.J.[6], [1]Department of Biology, University of Waterloo, Waterloo, ON, N3G 2L1; [2]Great Lakes Fishery Commission, 2100 Commonwealth Blvd, Suite 100, Ann Arbor, MI, 48105; [3]US Fish and Wildlife Service, Green Bay Fishery Resources Office, 2661 Scott Tower Drive, New Fraken, WI, 54229-9565; [4]Department of Fisheries and Oceans, 500 University Cres, Winnipeg, MB, R3T 2N1; [5]Michigan Department of Natural Resources, Marquette Fisheries Research Station, 484 Cherry Creek Rd, Marquette, MI, 49855; [6]University of Wisconsin - Stevens Point, College of Natural Resources, 800 Reserve Street, Stevens Point, WI, 54481. **Trophic ecology and isotopic niche of humper Lake Trout *Salvelinus namaycush* in Lake Superior: comparisons with other morphotypes.**

Relatively little is known about the trophic ecology of humper Lake Trout in Lake Superior. Results from studies of gut contents and stable isotope ratios indicate that while lean and siscowet Lake Trout overlap somewhat in depth distribution, the trophic niches of the two morphotypes do not overlap. This partitioning of resources has implications for restoration of lean Lake Trout; some speculated that siscowets could reduce prey densities to the point that restoration efforts for leans would be hampered, but the concurrent recovery of both morphotypes suggests otherwise. With the use of humpers in Lake Trout restoration stocking for other Great Lakes (i.e., Michigan, Erie), it is critical that we quantify trophic niche overlap between humper Lake Trout and the other two morphotypes. Using stomach content, fatty acid, and stable isotope data, we are launching a study in 2014 to investigate: 1) How trophic position and base of production differ between humper Lake Trout and the other two morphotypes; 2) How key sources of prey differ among the morphotypes; and, 3) The degree of isotopic niche overlap between humper Lake Trout and the other two morphotypes. Results will identify critical prey sources for humper Lake Trout, extend inferences of intraspecific competition among the morphotypes, and inform restoration efforts. *Keywords: Stable isotopes, Fatty acids, Lake Superior, Morphotypes, Lake trout, Gut contents.*

SWEENEY, S.J., ASPINALL, J.D., ERTELL, S.N., and STECKLEY, Z.J., Ontario Ministry of Agriculture and Food/ Ministry of Rural Affairs, Environmental Management Branch, Guelph, ON, N1G 4Y2. **Farming on the bluff: Agricultural land loss along Lake Erie's coast from Rondeau Bay to Long Point, 2006-2013.**

Sediment and nutrient loading from tributary agricultural landscapes has been implicated for contributing to the impairment of Lake Erie's aquatic ecosystem. Algal fouling in recent years has been notable for its expanse, intensity and duration. Water erosion of farmland has been a prime focus of monitoring and modelling efforts in tributary watersheds. Little or no attention has been paid to nutrient and sediment loads contributed to the lake by way of wholesale agricultural land loss to mass wasting processes along its Ontario coastline. Incremental coastal bluff recession along this shoreline has also concerned and impacted recreational landowners. This study focused specifically on coastal areas where farming activities occur on or adjacent to the bluffs. The Ontario Lake Erie coast from Rondeau Bay (RB) to Long Point (LP) was examined. A chronosequence of the shoreline-field situation between 2006 and 2013 at each of 24 study locations is presented. Undercutting of the bluffs by wave action and subsequent rotational slumping have resulted in many metres of land loss inland from the 2006 bluff edge positions at some of these locations over the past seven years. Much of this soil volume, including its contained nutrients, has been lost to the lake. *Keywords: Lake Erie, Shore bluff erosion, Agricultural land loss.*

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TAKARO, T.K.[1] and BOEHME, J.R.[2], [1]Simon Fraser University, Blusson Hall 11518, 8888 University Dr., Burnaby, BC, V5A 1S6; [2]IJC Great Lakes Regional Office, 100 Ouellette Ave., 8th Floor, Windsor, ON, N9A 6T3. **Source Water Monitoring as an Indicator of Risk to Human Health in the Great Lakes.**

The Health Professionals Advisory Board (HPAB) of the International Joint Commission (IJC) was asked by the Commission to provide a small set of indicators tying the assessment objectives of the Great Lakes Water Quality Agreement to the health of residents and resource users of the Great Lakes. To meet this request, the HPAB considered the tight

link between ecological and human health, and identified two candidate apex indicators associating human health risk from drinking water with source waters of the Great Lakes. Details on the rationale and process for developing a source water hazards approach for indicators and their associated measures will be presented for the 1) Chemical Integrity of Source Water Indicator and 2) Biological Hazard Index of Source Water. Measures for the Chemical Integrity of Source Water for include three representative compounds for agricultural pesticides (atrazine), endocrine disrupting compounds (estrogenicity assay) and harmful algal blooms (cyanotoxin levels). The Biological Hazard Index can be assessed for the impacts of human and agricultural activities by measures of key waterborne pathogens (E. coli; Cryptosporidium parvum; Giardia lamblia), chemical markers for septic systems and agriculture (nitrate), and trends in clarity of Great Lakes source waters (turbidity) to complete the index. *Keywords: Water quality, Human health, Indicators.*

TANG, R.W.K.[1], GANDHI, N.[2], BHAVSAR, S.P.[3], DROUILLARD, K.G.[2], and ARHONDITSIS, G.B.[1], [1]University of Toronto, Toronto, ON; [2]University of Windsor, Windsor, ON; [3]Ontario Ministry of the Environment, Toronto, ON. **Significance of toxaphene in Great Lakes fish consumption advisories.**

Fish consumption advisories have been issued for the Great Lakes generally based on the most restrictive contaminant. For the Canadian waters of the Great Lakes, toxaphene causes 3% restrictions only in Lake Superior. However, the significance of the hazard posed by toxaphene in fish is not clear since more restrictive advisories due to other priority contaminants may be masking the less restrictive advisories. We simulated fish consumption advisories for the Toxaphene-only scenario by neglecting the presence of contaminants other than toxaphene. Restrictive advisories under the Toxaphene-only scenario compared to the issued toxaphene related advisories would increase from 3% to 14%, <1% to 4%, and 0% to 2% for Lakes Superior, Huron and Ontario, respectively, and remain at 0% for Lake Erie. For Lake Superior, most of the restrictive Toxaphene-only advisories would be for fatty fish. Overall, the Toxaphene-only advisories would be significantly less restrictive compared to the issued advisories, and also generally less restrictive compared to the Mercury-only scenario. These results suggest that toxaphene is less of a concern than PCBs, dioxins-furans and mercury from the perspective of health risk to humans consuming Great Lakes fish; elevated toxaphene is mainly a concern for human consumers of Lake Superior fatty fish. *Keywords: PBTs, Toxaphene, Fish, Human Health, Lake Superior, Consumption Advisories.*

TAYLOR, D.R. and CHOW-FRASER, P., McMaster University, 1280 Main Street West, Hamilton, ON, L8S 4K1. **Long-term effects of impoundment on ecosystem functions of coastal wetlands in Georgian Bay.**

Water-level fluctuations maintain high aquatic biodiversity in coastal marshes of the Great Lakes, by preventing formation of dense mono-cultures of marsh vegetation. We hypothesize that a loss of hydrologic connection with the Great Lake would lead to altered water chemistry and an expansion of emergent vegetation at the expense of aquatic habitat. We predict that an impounded marsh would have lower fish diversity, increased larval amphibian abundance, but no difference in the marsh-bird community compared with a marsh that is hydrologically connected with the large lake. In this study, we investigate the effect of long-term loss of hydrologic connection between coastal marshes and Georgian Bay on ecosystem functions in the wetland. First, we documented the long-term changes in a marsh that had been impounded over 80 years ago and compare it with one which had never been impounded. Secondly, we compared the food webs of a chain of coastal marshes that were sequentially impounded by beavers over the past 5 decades. In both cases, we found no significant differences in the marsh-bird communities but significant differences in water chemistry, vegetation, fish and amphibian communities when impounded wetlands were compared with undiked marshes. We do not recommend diking or damming as an adaptation to low water levels. *Keywords: Coastal wetlands, Fisheries, Ecosystems.*

TAYLOR, W.D.[1], CHOMICKI, K.M.[1], HOWELL, E.T.[2], DEFIELD, E.M.[1], and DUMAS, A.G.[1], [1]Department of Biology, University of Waterloo, Waterloo, ON, N2L 4G1; [2]Environmental Monitoring & Reporting Branch, Ontario Ministry of the Environment, Etobicoke, ON, M9P 3V6. **Total, Particulate, and Mussel Phosphorus Distribution Patterns in the Nearshore of Lake Erie Adjacent to the Grand River, Ontario.**

Conditions adjacent to the Grand River in Lake Erie are highly dynamic due to the interacting effects of lake circulation and river discharge. Despite management efforts in the Grand River catchment, nutrients in the adjacent nearshore are adequate to support nuisance algal growth and proliferation of dreissenid mussels. The Ontario Ministry of the Environment monitored the region around the Grand River mouth in 1998 and 2001, mapping nutrient patterns as well as currents and water temperature at high resolution. In 2010, water quality, including speciation of particulate phosphorus, was measured at five stations. Also in 2010, benthic surveys were completed along 5 transects extending away from shore to 18 m water depth. Nearshore nutrient distributions followed the path of the Grand River plume. Particulate non-apatite inorganic phosphorus was higher in the river than in the nearshore zone, however, this bioavailable form of P was still the dominant form in the nearshore. Mussel populations were elevated within regions of mixing and elevated nutrient levels. This presentation will examine the spatial pattern of nutrients, particularly phosphorus, within the nearshore zone and relate phosphorus patterns and the bioavailability of particulate phosphorus to mussel distributions and mussel phosphorus content. *Keywords: Phosphorus, Zebra mussels, Coastal processes.*

THOMA, S.M. and MCNAUGHT, A.S., Central Michigan University, Mount Pleasant, MI, 48858. **Evaluating the role of *Hemimysis anomala* in the food webs of spawning reefs in Lakes Michigan and Huron: a stable isotope approach.**

Ponto-Caspian species have distinct phylogenentic and ecological characteristics that allow them to exert disproportionate effects on non-native ecosystems. A recent Ponto-Caspian invader of the Laurentian Great Lakes, the predatory crustacean *Hemimysis anomala*, exhibits behavioral and life history characteristics that may enable it to substantially alter the food web by either (1) inflicting heavy predation on lower food web organisms, thus reducing energy flow to higher trophic levels, or (2) serving as a new resource for fish, thus creating an energy pathway between primary/secondary production and higher trophic levels. We sampled seven sites spanning a range of *Hemimysis* densities in Lakes Michigan and Huron from May-October 2013. *Hemimysis* densities were measured monthly via vertical net hauls at night. Fish species and additional invertebrates representing common fish prey were collected at each site from September-October 2013 and analyzed for carbon and nitrogen ($\delta C^{13}$ and $\delta N^{15}$) stable isotopes. Preliminary results suggest a higher reliance on Hemimysis as a food source with increasing mysid densities. Therefore, *Hemimysis* may have the ability to temporarily lengthen the food webs in systems where adequate densities exist. *Keywords: Invasive species, Food chains, Isotope studies.*

THOMAS, V.J. and ORR, E., Central Algoma Freshwater Coalition, PO Box 159, Desbarats, ON, P0R 1E0. **Engaging Citizen Scientists: The Importance of Public Outreach and Education in Order to Protect Our Local Watersheds in the Great Lakes Basin.**

The Central Algoma Freshwater Coalition (CAFC) is a not-for-profit organization dedicated to the protection, improvement and restoration of watersheds throughout the Central Algoma Region. CAFC was formed in 2009, in response to concerns from property owners regarding cyanobacteria (blue-green algae) blooms recurring on several watersheds (all flowing into Lake Huron), and has since expanded its focus to include all aspects and activities related to healthy watersheds. Through many valuable partnerships with municipalities, businesses, property owners and government organizations, CAFC has conducted scientific studies to determine possible sources of nutrient loading, held boat washes and public education events to raise awareness on how to stop the introduction and spread of invasive species, organized workshops to help residents understand the importance of proper septic system maintenance, helped to create working groups and Lake Associations for an individualized focus on lakes within Central Algoma, and have trained and engaged citizen scientists to conduct water sampling on various lakes, as part of the MNR's Lake Partners Program. CAFC believes that working with the people and communities is the only way to truly develop sustainable, long-term, positive changes that will protect our local watersheds. *Keywords: Citizen science, Partnerships, Outreach, Stakeholders, Education, Voluntary change.*

TIMM, M.A., 6260 S. Lake Dr. Apt. 608, Cudahy, WI, 53110. ***Mussel Madness*: Can a Board Game Teach the Next Generation about Great Lakes Grand Challenges and Prepare Society for Solutions?**

Of the critical gaps identified at Great Lakes Futures Project workshops in 2013, three were improving education, building the sense of shared Great Lakes culture, and bolstering science communication to policymakers. These gaps are frequently lamented, yet precious few creative efforts truly bridge them. Still fewer products promise a sea change on this widely acknowledged critical societal weakness. What if we are looking at these gaps in the wrong way? What if they represent opportunity? What if a successful entertainment product could educate as it engages and create culture as it connects the public to science? *Mussel Madness* is a game born on this premise. Currently being beta-tested in Milwaukee among youth ranging from grade four to grad student, *Mussel Madness* is akin to *Monopoly* in the Great Lakes. Players compete or cooperate within and across boundaries to optimize the health, productivity, and profit of their respective Great Lakes--as ecological threats, ranging from invasive species to climate change, mount with every roll of the dice. How can the stewards of the basin "win"? Products like *Mussel Madness* provide a novel avenue to engage the public to educate their representatives to make wise policy decisions. *Keywords: Public education, Great Lakes basin, Mussels.*

TISUE, G.T., Duck Creek Watershed Assembly/White River Watershed Partnership/White Lake Association, 4388 Duck Lake Road, Whitehall, MI, 49461-9722, United States. **Volun-**

**teer Lake & Stream Monitoring: Experience with the Michigan Clean Water Corps Programs.**

Two programs of the Michigan Clean Water Corps (MiCorps) serve the needs of volunteer-based lake and stream monitoring efforts by providing training, equipment, analytical services, quality assurance protocols, technical back-stopping, and a secure database. The Cooperative Lakes Monitoring Program emphasizes measures of trophic status and aquatic macrophyte surveys. The Volunteer Stream Monitoring Program focuses on benthic macro invertebrates and stream habitat characterization, and also provides limited competitive grant funds to support start-up initiatives. The recent experiences of two West Michigan watershed organizations illustrate several strengths of the MiCorps approach, but also help define limitations imposed by modest funding levels currently available from both State and local sources. A key feature of these two watershed organizations is their nearly complete reliance on volunteers, not only for manpower but for professional expertise as well. This presentation will underscore why mobilization of local scientific and managerial expertise deserves emphasis in efforts to encourage citizen science. Our experience shows that MiCorps programs can provide an appropriate mechanism. *Keywords: Macroinvertebrates, Volunteer programs, Monitoring, Aquatic plants, Water quality.*

TOZER, D.C., Bird Studies Canada, P.O. Box 160, 115 Front Street, Port Rowan, ON, N0E 1M0. **The Great Lakes Marsh Monitoring Program: 18 Years of Surveying Birds and Frogs as Indicators of Ecosystem Health.**

Bird Studies Canada's Great Lakes Marsh Monitoring Program has operated annually since 1995. Volunteer citizen scientists record abundance of birds and frogs at points in emergent wetlands 2-3 times per breeding season. Call broadcasts are used to increase detections of secretive birds. Approximately 270 volunteers survey 1200 stations throughout the Great Lakes basin per year. Populations of 6 of 7 (86%) marsh-dependent breeding bird species significantly declined between 1995 and 2012 across the basin. By contrast, occurrence of 6 of 8 (75%) frog species showed no significant trend. Data across multiple species and years suggested that marsh ecosystem health was lower at coastal marshes and within Areas of Concern (AOCs) than at inland marshes and outside AOCs. Wetland loss and environmental stress linked to human population growth surrounding coastal marshes and within AOCs probably contributed to these patterns. The prevalence of declining and stable populations suggests that marsh ecosystem health has not improved in the Great Lakes basin. With its well-designed surveys, extensive wetland sampling, and engagement of citizen scientists, the program fills a unique niche among bird and frog monitoring programs in the Great Lakes basin. *Keywords: Monitoring, Indicators, Citizen science.*

TRENOUTH, W.R.[1], GHARABAGHI, B.[2], and FARGHALY, H.[2], [1]School of Engineering, University of Guelph, 50 Stone Road East, Guelph, ON, N1G 2W1; [2]Ontario Ministry of Transportation, Design and Contract Standards Office, 301 St. Paul Street, St., St. Catherines, ON, L2R 7R4. **A novel highway drainage system for application in salt vulnerable areas.**

Highway stormwater runoff from roadways typically comprises a complex chemical cocktail of pollutants including heavy metals, sediments, nutrients, petroleum hydrocarbons and, in cold climates, road salts. Many transportation authorities have turned their attention to the control and mitigation of the adverse environmental effects of highway runoff, particularly in vulnerable groundwater recharge areas. Road salts, dissolve into highly mobile ions, are capable of contaminating both surface and groundwater. This presentation focuses on novel solutions, with a particular emphasis on research currently taking place at the University of Guelph in conjunction with the Ontario Ministry of Transportation (MTO). A newly-designed field facility has been installed along a research section of Highway 401 - the busiest highway in Canada. Now in its second year of operation, monitoring of the treatment facility seeks to evaluate the attenuation capacity of a linear treatment system for stormwater runoff and to determine field performance of impermeable barriers in protecting sensitive groundwater areas from pollutant contamination. The preliminary results from this research suggest that stormwater runoff from highways can be improved significantly for the benefit of aquatic species and municipal use when using the novel system. *Keywords: Water quality, Urban areas, Transportation.*

TROY, C.D.[1], CANNON, D.[1], CHOI, J.M.[1], BOOTSMA, H.A.[2], and LIAO, Q.[2], [1]Purdue University, School of Civil Engineering, 550 Stadium Mall Drive, West Lafayette, IN, 47907; [2]University of Wisconsin-Milwaukee, Water Institute, 600 E. Greenfield Ave., Milwaukee, WI, 53204. **Year-round characterization of a deep-water Lake Michigan bottom boundary layer.**

We report results on a benthic boundary layer experiment carried out near Milwaukee, WI, in waters of 55m depth. The experiment was designed to characterize the seasonal variability in the bottom boundary layer currents and structure. Measurements suggest a very sluggish bottom boundary layer with a time-varying thickness that is most often limited by

weak near-bottom thermal stratification. Velocity profiles very close to the lake bed are logarithmic, with increasing logarithmicity for high-speed episodes. Elevated near-bed currents and turbulent intensities are seen to be associated with episodic events such as downwellings and large surface waves. Turbulent kinetic energy values are found to scale with the bed friction velocity, as expected, with values very close to the bed elevated well beyond expected values; these elevated near-bed values may be indicative of mussel-enhanced turbulence. A simple 1-D vertical model highlights the importance of benthic turbulence and its spatio-temporal variability on the ability of quagga mussels to clear the water column. *Keywords: Lake Michigan, Turbulence, Hydrodynamics, Mussels.*

TRUMPICKAS, J.J. and DUNLOP, E.S., Ontario Ministry of Natural Resources, 2140 East Bank Dr., Peterborough, ON, K9J 7B8. **The effect of habitat and shoreline alterations on nearshore small fish community structure in Lake Simcoe.**

Nearshore small fishes represent a large proportion of the fish biodiversity of Lake Simcoe. Over the past several decades, the species richness of this community has declined and the species composition has changed. However, drivers of community change remain unclear. The goal of this study is to understand how nearshore habitat and shoreline alterations shape the small fish community in Lake Simcoe. Nearshore small fishes were sampled using gillnets, fyke nets and seine nets in 2011-2013 along the southeastern shoreline of Lake Simcoe in both June and August. Habitat was assessed using side-scan sonar and visual observations. Shoreline alterations, such as docks and breakwalls, were recorded at fish sampling sites. Fish communities showed little change between years. Sampling methods were refined by assessing differences in the detectability of key species between different gear types and sampling periods (June vs. August). Analyses explored relationships between fish communities, habitat and shoreline alterations. Understanding the roles of habitat and shoreline alterations in structuring the small fish community can help elucidate drivers of recent observed changes in the fish community and inform strategies for fish community management. *Keywords: Fish populations, Lake Simcoe, Littoral zone.*

TRUONG, J.[1], DIAMOND, M.[1], JANTUNEN, L.[2], and HELM, P.[3], [1]Department of Chemical Engineering and Applied Chemistry, University of Toronto, 200 College Street, Toronto, ON, M5S 3E5; [2]Environment Canada, 6248 8th Line, Egbert, ON, l0l 1N0; [3]Great Lakes Environmental Monitoring and Reporting Branch Ontario Ministry of the Environ-

ment, 125 Resources Road, West Wing, Toronto, ON, M9P 3V6. **Organophosphate Ester Concentrations in the Great Lakes St. Lawrence Seaway.**

Organophosphate esters (OPE's) are commonly used as plasticizers, lubricants and as flame retardants to replace the recently phased-out Brominated Flame Retardants. OPEs are a concern because of new reports of high concentrations indoors and in waters, their bioaccumulation potential in herring gull eggs and fish, and their potential toxicity to aquatic biota and humans. Since OPE's are typically employed as additives and are not chemically bonded, they are subject to release into the environment via volatilization, dissolution and abrasion. Recent studies have found them in the Artic, suggesting long-range transport capability. In the summer of 2013, surface water samples were collected at urban and remote sites in the Great Lakes St. Lawrence Seaway to determine concentrations of several OPE's. Preliminary data suggest that tributaries and urban areas have concentrations an order of magnitude higher than more remote areas of the waterway. These data match data previously reported by, Jantunen (2013) of halogenated and non-halogenated OPE's in Toronto urban streams which ranged from 10-1600 ng/L. From this study, we aim to pinpoint the major transport pathways of OPE's into Lake Ontario. *Keywords: Environmental contaminants, Organophosphate Esters, Great Lakes basin, Emerging Contaminants, Organochlorine compounds.*

TURSCHAK, B.A.[1], BUNNELL, D.B.[2], CZESNY, S.[3], HÖÖK, T.O.[4], JANSSEN, J.[1], WARNER, D.M.[2], and BOOTSMA, H.A.[1], [1]University of Wisconsin-Milwaukee, School of Freshwater Sciences, 600 E. Greenfield Ave., Milwaukee, WI, 53204; [2]USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105; [3]Lake Michigan Biological Station, 400 17th Street, Zion, IL, 60099; [4]Purdue University, Department of Forestry and Natural Resources, 195 Marsteller Street, West Lafayette, IN, 47907. **Spatial Variability in the Trophic Structure of Lake Michigan Fishes as Revealed by Stable C and N Isotopes.**

Spatial differences in the food web structures of large lakes are difficult to determine, but have important management implications. We used stable carbon and nitrogen isotopes to elucidate differences in primary energetic source and trophic level of Lake Michigan fish species from 2010-2013. Fish and invertebrates were collected from 9 nearshore sites and 3 offshore sites around the Lake Michigan basin for stable isotope analyses. Stable C isotope ratios were consistently lighter for nearshore, pelagic, and profundal fish in the eastern portion of the basin relative to those in the western portion. These results suggest greater reliance on pelagic energy sources in the east versus nearshore benthic reliance in the west, which corresponds to the dominant substrate type (sand vs. rock, respectively) in these regions. Stable N isotope ratios varied spatially, with pelagic and profundal species collected in the northern basin being enriched relative to conspecifics from the southern basin. This pattern was not apparent for nearshore fishes, and so it does not appear to be driven by spatial differences in allochthonous N loading. Rather, it may reflect large-scale differences in pelagic food web structure or pelagic nitrogen cycling. *Keywords: Fish populations, Fisheries, Diets.*

TUTTLE-RAYCRAFT, S. and ACKERMAN, J.D., Department of Integrative Biology, University of Guelph, 50 Stone Road E, Guelph, ON, N1G 2W1. **The effects of suspended sediment on the suspension feeding of unionid mussels.**

Discerning the role of suspended solids (SS) on aquatic organisms and biogeochemical processes is imperative and unionid mussels provide an excellent model system for investigation. Experimental results revealed that SS concentration > 8 mg/L significantly lowered the clearance rates (CR) of adult *Lampsilis siliquoidea* (shell length = 9-12 cm) by at least 28% compared to CR = 0.87 ± 0.052 L $hr^{-1}$ in no sediment. This result was not consistent among SS of different grain size. Analogous experiments performed on newly transformed *Lampsilis fasciola* (shell length = 304.5-327.2 µm) revealed similar CR vs. SS results (i.e., 32% decrease vs. 0.24 ± 0.026 mL $hr^{-1}$) for juvenile mussels older than two weeks. In contrast, CR were positively related to SS concentration ($R^2$ = 0.67) for one week old animals where CR were 25% higher than control (CR = 0.17 ± 0.010 mL $hr^{-1}$) when >8 mg/L. Understanding how physical processes affect SS concentrations in lakes and rivers will provide valuable information on ecosystem function. Moreover, it will further our understanding of unionid biology, the role they play in water quality, and assist in the management and conservation within the Great lakes Ecosystem. *Keywords: Unionids, Biogeochemistry, Sediments, Turbidity.*

TWISS, M.R.[1], SALK, K.R.[2], AVOLIO, L.N.[1], CHAPPAZ, A.[3], and OSTROM, N.E.[2], [1]Department of Biology, Clarkson University, Potsdam, NY, 13676; [2]Department of Zoology, Michigan State University, East Lansing, MI, 48824; [3]Department of Earth and Atmospheric Sciences, Central Michigan University, Mountr Pleasant, MI, 48859. **Seasonal Differences in Trace Metal (Fe, Mo) Stimulation of Photosynthesis and Nitrate Assimilation in the Deep Chlorophyll Layer (DCL) of Lake Ontario.**

Lake Ontario has undergone a steady increase in nitrate since the early 1970s. Possible causes include rising urban and agricultural runoff, atmospheric deposition, and less demand for N due to effective point source P control. Molybdenum (Mo) and iron (Fe) are involved in reductive nitrate assimilation to protein so that nitrate assimilation in Lake Ontario may be limited in phytoplankton by low trace metal bioavailability. To test this hypoth-

esis, five 1-d enrichment experiments were conducted using trace metal clean techniques in June and September 2013 on water sampled from the metalimnion of Lake Ontario, and three 4-d enrichment experiments were conducted in July 2013 on main channel waters of the St. Lawrence River, the outflow of Lake Ontario. Enrichment with Fe, Mo, or P alone stimulated photosynthetic efficiency (measured as Fv:Fm) but only P alone or with Fe & Mo caused notable $^{15}$N-NO3 assimilation. Fe and Mo are clearly bioactive elements in the water column and were more stimulatory earlier in the season when nitrate was at higher concentrations in the water column and the N:P ratio was lower. Mo enrichments elicit biotic response but the dissolved Mo versus depth profiles reflects that of a conservative element. The sulfate to molybdate ratio in Lake Ontario could be inhibiting nitrate assimilation. *Keywords: Nutrients, Iron, Phytoplankton, Deep Chlorophyll Layer, Lake Ontario, Molybdenum.*

# U

UPSDELL WRIGHT, B.L.[1], LIU, Y.B.[2], VELIZ, M.[1], YANG, W.[2], SIMMONS, E.J.[2], and LOWENSTINE, M.R.[1], [1]Ausable Bayfield Conservation Authority, 71108 Morrison Line, Exeter, ON, N0M 1S5; [2]University of Guelph, 50 Stone Road East, Guelph, ON, N1G 2W1. **Seasonal Loadings of Sediment and Nutrients from the Gully Creek Watershed to Lake Huron.**

The nearshore area of the Great Lakes provides many residents of Ontario with drinking water and recreational opportunities; however, the impacts of tributary nutrient and sediment inputs can sometimes limit both the human uses and the ecological integrity of these nearshore waters. As part of a watershed-based evaluation of agricultural best management practices (BMPs) in Huron County, the Soil and Water Assessment Tool (SWAT) was adapted for the Gully Creek watershed (15 km$^2$) to simulate hydrologic processes and water quality. The SWAT simulation showed that most of the stream flow and sediment and total phosphorus (TP) loadings were concentrated in the winter season. Total nitrogen loading, by contrast, peaked in May. These results indicate that winter monitoring of water quality is crucial to estimating realistic loadings of sediment and TP to the Great Lakes. In addition, BMPs must be designed to effectively retain sediment and phosphorus on the landscape through the winter and prevent nitrogen loss in the spring. An analysis of loading estimates from intensive year-round monitoring will also be presented. *Keywords: Water quality, Nutrients, Loading, Lake Huron, Sediments, Watershed modeling.*

URBAN, N.R., KERFOOT, W.C., PADILLA, J.A., and XUE, P., Michigan Technological University, Houghton, MI, 49931. **Towards an Ecological Assessment of Mining Impacts on Nearshore Lake Superior.**

The nearshore coastal zone transmits impacts from land to the open lake and vice versa. The historical legacy of copper mining on the Keweenaw Peninsula (1840-1995) allows us to examine some of the myriad connections from land to lake that pass through and impact ecological processes in the nearshore coastal zone. This talk focuses on the broader picture of cumulative impacts of land-based activities (mining) on ecological processes in the nearshore coastal zone. These impacts range from physical habitat alterations to chemical effects to resultant biological impacts. Material flows of a host of secondary substances in addition to primary contaminants have been altered. This talk will present some preliminary depictions of the biogeochemical alterations, but a complete ecological assessment is still a long ways off. *Keywords: Coastal ecosystems, Mining, Lake Superior, Environmental effects.*

UZARSKI, D.G.[1], CLEMENT, T.A.[1], SCHUBERG, D.H.[1], SCHOCK, N.T.[1], and COOPER, M.J.[2], [1]Institute for Great Lakes Research, CMU Biological Station, Department of Biology, Central Michigan University, Brooks 127, Mount Pleasant, MI, 48859; [2]Department of Biological Sciences, University of Notre Dame, 107 Galvin Life Sciences, Notre Dame, IN, 46556. **A Basin Wide Great Lakes Coastal Wetland Monitoring Program: Metrics to Evaluate Ecosystem Health.**

The Great Lakes Coastal Wetlands Consortium was formed in 2000 to develop a basin wide monitoring plan to determine status and trends of ecosystem health using indices of biotic integrity. The plan was finalized in 2008 and implementation began in 2010. Implementation of the monitoring plan involved the collection of chemical and physical parameters, vegetation, invertebrate, fish, amphibian, and bird data from randomly selected Great Lakes coastal wetlands across the basin using standardized protocols. Sampled wetlands were selected using a stratified random design. This design was intended to inform future protection and restoration efforts by measuring both the status and trends of coastal wetland ecosystem health. As we have accumulated more data, we have continuously sought to improve our IBIs and individual metrics of ecosystem health. We used land use and cover data in conjunction with chemical and physical data, collected in situ, to establish an a priori disturbance gradient by year. Additionally, we used non metric multi-dimensional scaling, principal components analysis, and Pearson correlation to evaluate current methods, spatially and temporally, while developing new ones. This process of adaptive management as new data are acquired, greatly enhances the effectiveness of our long-term monitoring project. *Keywords: Coastal wetlands, Indicators, Monitoring.*

# V

VAN ESBROECK, C.J.[1], MACRAE, M.L.[1], BRUNKE, R.[2], and MCKAGUE, K.[3], [1]Dept. of Geography and Environmental Management, University of Waterloo, Waterloo, ON; [2]Ontario Ministry of Agriculture and Food, London, ON; [3]Ontario Ministry of Agriculture and Food, Woodstock, ON. **Field-scale phosphorus transport from reduced tillage systems via overland flow and tile drainage in southwestern Ontario.**

The non-growing season (NGS) can contribute a large portion of annual phosphorus (P) loading from agricultural fields via overland flow and tile drainage. Reduced tillage systems have been shown to decrease losses of particulate P, but may increase the risk of dissolved P transport in some situations. Discharge and P transport as overland flow and tile drainage were monitored at two field-scale sites in southwestern Ontario for one year to address the following objectives: (1) the quantification of runoff and P loads from two reduced-till agricultural fields; and, (2) to characterize seasonality in the relative contributions of tile drainage and overland flow to annual loads, and to demonstrate variable responses among different event types. The NGS accounted for the majority of annual P loading, and most of these losses were generated by a series of discrete discharge events that included overland flow. The characteristics of discharge events (e.g. rain on soil, rain on snow, and radiation melt) influenced both P mass and speciation in runoff, making it challenging to make generalizations regarding the contributions of winter events. Given the importance of the NGS to annual P losses, we suggest that agricultural best management practices for southern Ontario should be appropriate for conditions experienced during the NGS. *Keywords: Phosphorus, Tile drainage, Water quality, Reduced tillage, Nutrients.*

VAN METER, K.J. and BASU, N.B., University of Waterloo, 200 University Ave. W., Waterloo, ON, N2L 3G1. **Spatial-Temporal Patterns in Streamflow and Nutrient Fluxes Across the Grand River Watershed: Emerging Simplicity or Confounding Complexity?**

With agricultural intensification, rivers and streams flowing through managed catchments have become delivery channels for excess nutrients, leading to problems of eutrophi-

cation and posing risks to drinking water safety. In the Grand River Watershed of southern Ontario, row-crop agriculture and concentrated livestock operations dominate both the upper and lower areas of the basin, while the middle of the watershed is increasingly urban, leading to modified flow regimes and nutrient concentrations commonly above provincial water quality guidelines. Despite interventions to reduce nutrient concentrations, including the ban on detergent phosphorus, upgrades in wastewater treatment plants, and the implementation of farm-level best management practices, eutrophication continues to present significant water quality problems. It is our hypothesis that this persistence stems from the presence of biogeochemical nutrient legacies within the landscape, leading to lag times between changes in nutrient management and improvements in water quality. In this work we explore spatial and temporal patterns of streamflow and nutrient fluxes across the Grand River Watershed to identify hot spots and hot moments in biogeochemical nutrient cycling, with particular attention being given to seasonality. *Keywords: Nutrients, Grand River, Eutrophication.*

VANDEN BYLLAARDT, J. and ACKERMAN, J.D., Department of Integrative Biology, University of Guelph, Guelph, ON, N1G 3A7. **Hydrodynamic habitat influences suspension feeding by unionid mussels in freshwater ecosystems.**

The influence of hydrodynamics on benthic suspension feeders remains largely unknown, especially for freshwater unionid mussels. We examined how seston flux affected the suspension feeding of unionid from different hydrodynamic habitats. Fluorometric measurements of algal depletion in a recirculating flow chamber were used to determine the clearance rate (CR) of four unionid species: *Elliptio complanata, Elliptio dilatata, Fusconaia flava* and *Strophitus undulatus*. CR varied with algal flux for all species examined, resulting in a 41-fold increase in CR for some species, compared to no-flux controls. Importantly, the results from the no-flux controls were consistent with published CR values obtained under static conditions. *E. dilatata* from the fastest flowing lotic system (Grand River, ON) cleared up to 4 times more algae than any other species, including its conspecifics from a slower flowing river (Ausable River, ON) and the species from the lentic habitat (*E. complanata*; Lake Opeongo, ON). Differences in CRs were also found among *E. dilatata, F. flava* and *S. undulatus* from the Ausable River at the highest flux examined. The impact of suspension feeding by unionid in the Great Lakes Ecosystem has probably been underestimated, especially under lotic and high flux conditions. *Keywords: Ecosystems, Mussels, Water quality.*

VANDERPLOEG, H.A.[1], RUTHERFORD, E.S.[1], KRUEGER, D.[2], MASON, D.M.[1], LIEBIG, J.R.[1], CAVALETTO, J.F.[1], FAHNENSTIEL, G.L.[1], NALEPA, T.F.[1], POTHOVEN, S.A.[1], RUBERG, S.A.[1], CONSTANT, S.[1], and BUNNELL, D.B.[3], [1]GLERL/NOAA, Ann Arbor, MI, 48108; [2]Michigan State University, East Lansing, MI, 48823; [3]Great Lakes Science Center USGS, Ann Arbor, MI, 48105. **Life on the Edge: The Spatial Structure of the Food webs of Lakes Michigan and Huron Before and After the Dreissenid Invasion.**

We used a variety of technologies to examine diel spatial structure of the food webs of Lake Michigan. Due to tributary loading and mussel distribution, Lake Huron and northern Lake Michigan showed low concentrations of plankton nearshore, whereas Michigan showed high concentrations nearshore. Phytoplankton, zooplankton, and fish abundance varied greatly in the horizontal as well as in the vertical dimensions. There was strong diel vertical migration of zooplankton that appeared to be driven proximally by both diel light cycle and thermal structure. Many zooplankton species congregated in the day in the upper hypolimnion or in the metalimnion regardless of its depth or location of the deep chlorophyll layer. Dreissenids associated with the mid-depth sink have depleted chlorophyll concentrations during all times of year and have restructured not only vertical distribution but also horizontal distribution of chlorophyll. Vertical distribution of different zooplankton species can be defined in terms of thermal habitat preference. Nearshore zooplankton communities consist of epilimnetic species found offshore; however, fish predation results in dominance by smaller zooplankton species nearshore. Detailed information such as this is necessary to understand ecosystem function and fisheries recruitment. *Keywords: Ecosystems, Lake Michigan, Lake Huron.*

VANNIJNATTEN, D.L.[1], BRYK-FRIEDMAN, K.[2], JOHNS, C.M.[3], and KRANTZBERG, G.[4], [1]Wilfrid Laurier University, Waterloo, ON, N2L 3C5; [2]University of Buffalo, Buffalo, NY; [3]Ryerson University, Toronto, ON; [4]McMaster University, Hamilton, ON. **Transboundary Governance Capacity: Towards Indicators and an Analytical Framework.**

Despite the many cooperative mechanisms already in place to address water quality and quantity issues in the Basin, the governance framework appears to have been modestly successful, particularly if we look across issues. While the regime regulating water "takings" and water levels provides has successfully shaped the behaviour of actors around the Basin, protecting the quality of the water has been a more difficult (Sproule-Jones 2002; Botts and Muldoon 2005; Johns 2009; Johns 2010; IJC 2013). What factors have contributed to this success/lack of success? In this paper, we present a matrix for assessing transboundary gov-

ernance capacity (TGC), which sets out five attributes we argue are necessary for effective TGC in the Great Lakes and, indeed, any transboundary water basin: high levels of leadership; necessary and sufficient membership; shared discourse and mutual understanding; sustainable resources; and strong institutional basis. For each of these attributes, we delineate Indicators, as well as proposed measures. We will also present findings from a comparative study across the fisheries, nearshore framework, invasive species, irrigation and AOCs cases. *Keywords: Great Lakes basin, Decision making, Indicators.*

VENKITESWARAN, J.J. and SCHIFF, S.L., Department of Earth and Environmental Sciences, University of Waterloo, 200 University Ave W, Waterloo, ON, N2L 3G1. **Linking aquatic metabolism, gas exchange, and hypoxia to impacts along the 300 km Grand River, Canada.**

The Grand River is a seventh-order 300km river in Ontario, Canada. Century-long watershed land-use changes are large and result in increasing agricultural and urban nutrient inputs to the river from source to mouth. Longitudinal and temporal changes in aquatic metabolism and reaeration were studied over three seasons using O2 and δ18O-O2. Diel O2 changes were over 50 percentage points. Some diel O2 changes were greater than 10 mg/L. Strong daily variation in δ18O-O2, up to 22%, was observed at all 23 sampling sites. Despite consistently high nutrient levels and productivity from headwaters to mouth, there were distinct impacts on O2 saturation as a result of WWTPs in all seasons. Modifications to river flow or nutrient inputs affecting reaeration or O2 demand risk exacerbating current nighttime hypoxia problems. Strong diel O2 variability may not directly indicate increased metabolic rates because changes in reaeration coefficients mask changes in metabolism. WWTP nutrients had little effect on photosynthesis rates immediately downstream of the WWTPs. Thus, the WWTP zone of impact extends farther downstream than otherwise expected because of upstream agricultural nutrient loading. Though O2 is the measure used by ecosystem managers, we need to manage using metabolism and gas exchange to affect the desired O2 outcomes. *Keywords: Metabolism, Nutrients, Grand River.*

VERHAMME, E.M., DEPINTO, J.V., and REDDER, T.M., LimnoTech, 501 Avis Dr, Ann Arbor, MI, 48108. **Western Lake Erie Nutrient and HABs Modeling: 2011 & 2012 Comparisons.**

Western Lake Erie has experienced a resurgence of Harmful Algal Blooms (HABs) within the last decade. Of particular concern is the 2011 algal bloom, which was the largest

algal bloom since recent monitoring began that extended from Toledo to Cleveland and persisted through late October. In contrast there was not a large bloom the following year in 2012. This presentation will investigate the differences between 2011 and 2012 with specific emphasis on the Maumee River phosphorus load, which was near record levels in 2011. Results from a linked hydrodynamic-sediment transport-eutrophication model will be shown to connect nutrient loads to the growth and transport of harmful algal blooms in Western Lake Erie. *Keywords: Lake Erie, Nutrients, Harmful algal blooms.*

VIS, C.[1], KEITEL, J.[2], and DANIEL, C.[3], [1]Parks Canada, Protected Areas Establishment and Conservation Directorate, 25 Eddy St., 4th floor, Gatineau, QC, K1A 0M5; [2]Parks Canada, Lake Louise, Yoho & Kootenay Field Unit, P.O. Box 220, Radium Hot Springs, BC, V0A 1M0; [3]University of Toronto, Dept. of Ecology & Evolutionary Biology, 25 Wilcocks Street, Toronto, ON, M5S 3B2. **Predicting coastal wetland restoration outcomes using state-and-transition simulation models: a case study for Point Pelee National Park.**

Many Great Lakes coastal wetlands have undergone landscape-scale changes in vegetation including the expansion of cattails and more recent invasions by *Phragmites* which impact biodiversity, wildlife habitats and wetland functions. Given the limited resources available for restoration, modeling is one method that can be used to determine which actions on the ground are most effective and resilient in the long-term, before initiating any work. In this study, we developed state-and-transition simulation models (STSMs) for *Typha* and *Phragmites* dynamics in coastal wetlands, to predict changes in vegetation over time in response to natural disturbances and management. Calibrated using a ~50-year dataset from Point Pelee National Park, and management effectiveness data from the literature, we compared the outcomes and costs of various management scenarios, including mechanical, chemical and hydrological control methods. Results indicate that management strategies that control the *Phragmites*, with the longer term goal of re-creating openings by reducing the dominance of cattails in the wetland would be optimal to increase diversity and restore wetland ecosystem condition. *Keywords: Coastal wetlands, Phragmites australis, Invasive species.*

VISHA, A.[1], BHAVSAR, S.P.[2], and ARHONDITSIS, G.B.[1], [1]University of Toronto, Ecological Modelling Laboratory, Toronto, ON, M1C 1A4; [2]Ontario Ministry of the Environment, Toronto, ON. **Temporal PCB and mercury trends in Lake Trout and Walleye: A Bayesian modelling analysis from Lake Ontario.**

Mercury and PCBs are two of the most prevalent contaminants in the Great Lakes with particular interest for fish consumption. The goal of this study is to examine the temporal trends of the two contaminants in Walleye and Lake Trout from Lake Ontario. To address this research question, we employ three different modelling strategies: (i) Dynamic Linear Modelling (DLM); ii) Exponential Decay Modelling (EDM); and iii) Mixed Order Modelling (MOM). Because the latter two models postulate monotonic decrease of the contaminant levels, we included first-order random walk terms in our statistical formulations to accommodate non-monotonic patterns in the data time series. Our analysis sheds light on the role of different covariates (length, lipid content) that can potentially hamper the detection of the actual temporal trends of fish contaminants. We also examined the differences between males and females of the two species. Results indicate that DLMs more faithfully depict the yearly variation in contaminant concentrations relative to EDMs and MOMs. Both mercury and PCBs demonstrate decreasing temporal trends in both species and genders. PCB trends are more evident in Lake Trout than in Walleye. The opposite holds true with the mercury trends, suggesting that specific fish species can act as bio-indicators for specific contaminants. *Keywords: Management, Fish contamination, Mercury, Dynamic linear modelling, PCBs, Lake Ontario.*

VODACEK, A., Chester F. Carlson Center for Imaging Science, Rochester Institute of Technology, Rochester, NY, 14618. **Forecasting Yearly Variability in *Cladophora* Growth from Remote Measurements of Temperature and Turbidity.**

Previous work demonstrated that year-to-year variability in *Cladophora* accumulation at Ontario Beach in Rochester, NY USA during the summer could be predicted by statistical analysis of water temperature patterns during the spring. In this study that work is extended to include a factor related to nutrient and light availability in the spring using remotely sensed turbidity as a proxy. Cloud free images of the Rochester region from the MODIS ocean color dataset were analysed to assess the prevalence of turbidity in the nearshore for the years 2000 to 2010. The turbidity variable was included along with the previously determined temperature variable in a regression analysis with *Cladophora* accumulation as the dependent variable. The results are assessed in comparison to the prediction based on temperature alone and used to provide insight into the use of turbidity as a proxy for light availability and nutrient inputs during the spring. *Keywords: Remote sensing, Temperature, Turbidity, Lake Ontario.*

VOLIK, O.[1], DANESH, D.C.[2], MCCARTHY, F.M.G.[1], and DRLJEPAN, M.[1], [1]Brock University, 500 Glenridge Ave, St Catharines, ON, L2S 3A1; [2]Queen's University, 99 University Ave, Kingston, ON, K7L 3N6. **Temporal and spatial change in anthropogenic impact on Lake Simcoe: insights from pollen, non-pollen palynomorphs and thecamoebians.**

The distribution of microfossils in cores from Cook's Bay, Smith's Bay and the main basin shows response to temporal and spatial change in human impact on Lake Simcoe and its watershed. The most prominent changes in pollen, non-pollen palynomorph and thecamoebian assemblages appear to record historic events such as land clearing and population growth at the end of the 19th century, draining of the Holland Marsh (1925 - 1930) and post-WWII urbanization and industrialization. Variations in microfossil assemblages also match spatial differences in total phosphorus concentrations within the lake showing that the level of eutrophication decreases gradually northward. Evidence of high level of eutrophication, bottom hypoxia and heavy metal contamination is the most prominent in the non-pollen palynomorph and thecamoebian records from Cook's Bay. This coincides with the highest population and most intense agriculture in subwatersheds draining into Cook's Bay relative to other subwatersheds of Lake Simcoe. Microfossil assemblages from the core from Smith's Bay indicate a lower level of eutrophication. The absence of indicators of bottom hypoxia in the core from Smith's Bay is also consistent with continued high dissolved oxygen. *Keywords: Lake Simcoe, Eutrophication, Microfossils.*

# W

WANG, J.[1], BAI, X.[2], HU, H.[2], FUJISAKI, A.[2], and BELETSKY, D.[2], [1]NOAA Great Lakes Environmental Research Laboratory, 4840 S State Road, Ann Arbor, MI, 48108; [2]CILER, University of Michigan, 4840 S State Road, Ann Arbor, MI, 48108. **Great Lakes Ice and Climate: From Research to Forecast.**

Over the past six years (since 2007), GLERL and CILER team has studied Great Lakes ice and regional climate in response to global climate changes and how to transfer scientific research results into predictions of lake ice on the scales of several days to several months. It was found that both NAO and ENSO have linear and nonlinear impacts on lake ice, respectively, but neither of them solely dominates the Great Lakes regional climate and lake ice cover. The combined effects of both NAO and ENSO on lake ice provide high predictability skills using statistical regression models. The new findings were incorporated into a statistical regression model, which can project median-range lake ice cover only using pro-

jected NAO and Nino3.4 indices one to several months ahead. For the first time, fully-coupled Great Lakes Ice-circulation Models (GLIM) with both dynamics and thermodynamics have been developed at GLERL/CILER to simulate and investigate the lake ice variations on the synoptic, seasonal, interannual, and decadal time scales. The hindcast results were validated using in situ, airborne, and satellite measurements. The validated GLIM has been used since the 2010-2011 ice season to forecast Great Lakes ice cover concentration, thickness, velocity, and associated air-ice-sea variables for up to five days in advance. *Keywords: Model testing, Teleconnection patterns, Ice, Coupled Ice-circulation models, Climate change, Great Lakes.*

WANG, J.[1], LUO, L.[2], HU, H.[3], ROWE, M.D.[1], VANDERPLOEG, H.A.[1], and BAI, X.[3], [1]NOAA Great Lakes Environmental Research Laboratory, 4840 S State Road, Ann Arbor, MI, 48108; [2]South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou, GD, China; [3]CILER University of Michigan, 4840 S State Road, Ann Arbor, MI, 48108. **Modeling spring bloom in Lake Michigan with and without river-loaded nutrient.**

A 3-D coupled physical-biological model is used to simulate the ecosystem characteristics in Lake Michigan. The physical model is the unstructured grid, Finite-Volume Coastal Ocean Model (FVCOM) driven by the observed hourly meteorological forcing and river loaded nutrients in 1998. The biological model is a NPZD model, including phosphorus as the nutrient, which is the limiting element in Lake Michigan, phytoplankton, zooplankton and detritus. The model is calibrated by the satellite and in situ data. The main phenomena in the spring of 1998 are captured. During March to May, a circle-like phytoplankton bloom appears in South Lake Michigan, which looks like 'doughnut'. The formation and mechanisms of spring bloom were simulated. It is confirmed that the phytoplankton bloom along the coast is caused by the river-loaded nutrient in addition to rapid increasing temperature and light intensity in spring. Without the river loaded nutrient, the coastal bloom cannot be reproduced. River-loaded nutrient input was proven to be important Lake Michigan ecosystem, which is linked to regional climate change. *Keywords: Coastal ecosystems, Phytoplankton, Model studies.*

WANG, L.[1], SERVEISS, V.[2], JARJOUR, J.[3], ARVAI, A.[1], BOEHME, J.R.[1], BURROWS, M.J.[1], DEMPSEY, D.[2], and WILSON, J.[1], [1]International Joint Commission, Great Lakes Regional Office, 100 Ouellette Ave, Windsor, On, N9A 6T3; [2]International Joint Commission, Washington Section, 2000 L Street, NW, Suite #615, Washington, DC, 20036; [3]International Joint Commission, Ottawa Section, 234 Laurier Ave, West, 22nd Floor, Ottawa, ON, K1P 6K6. **IJC's Efforts in the Development of Great Lakes Indicators.**

Successful management of the Great Lakes ecosystems relies on effective evaluations of the tremendous efforts in protection and restoration of the integrity of the ecosystems. However, it has been proven challenging to identify a set of indicators for assessing those efforts in such complex and large systems. During the last two years, the International Joint Commission (IJC) has taken efforts to develop three sets of indicators that will enable IJC to fulfill its assessment of progress responsibilities specified in the Great Lakes Water Quality Agreement (GLWQA). Working with experts from its advisory boards, government and non-government agencies, environmental organizations, and academia representatives from both countries, IJC identified 16 ecosystem indicators for measuring physicochemical and biological integrity of the Great Lakes. The five human health indicators identified by IJC are most useful for better understanding and conveying risks resulted from recreational activities, consuming fish, or drinking water. The 4-10 management response indicators under development are useful for assessing the extent to which programs and other measures are achieving the objectives of the GLWQA. This presentation provides an overview of the indicator development process and uses examples to describe how the indicators are defined. *Keywords: Assessments, Assessments, Assessments.*

WAPLES, J.T., BOOTSMA, H.A., and KLUMP, J.V., School of Freshwater Sciences, 600 E. Greenfield Ave., Milwaukee, WI, 53204. **How is the Nearshore Benthic Community Fed? Estimating Lateral Transport of Pelagic Energy with Naturally Occurring Radionuclides.**

Many large lake studies have shown an imbalance between nearshore heterotrophic respiration (R) and local primary production (P), with P/R ratios < 1. Organic carbon fluxes that are required to sustain heterotrophic demand are often postulated to originate from terrestrial sources. Yet offshore subsidies to the nearshore are also plausible (but difficult to measure). Here we present estimates of lateral transport based on measurements of two radionuclide tracer pairs: U-238/Th-234 and Sr-90/Y-90 disequilibria. Calculated radionuclide fluxes and radionuclide/organic carbon/phosphorus ratios on suspended particles suggest onshore transport of pelagic material can dominate the supply of energy and nutrients to the nearshore benthos. *Keywords: Lake Michigan, POC flux, Coastal processes, Horizontal transport, Radioisotopes, PP flux.*

WARREN, G.J.[1], HORVATIN, P.J.[1], LESHT, B.M.[2], BUNNELL, D.B.[3], and SCHARDT, J.C.[1], [1]USEPA Great Lakes National Program Office, 77 W. Jackson Boulevard, Chicago, IL, 60604; [2]CSC and the University of Illinois at Chicago, 845 W. Taylor St., Chicago, IL, 60607; [3]USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105. **Lake Huron 2012 Cooperative Science and Monitoring Initiative Introduction.**

The Cooperative Science and Monitoring Initiative (CSMI) has a 5-year intensive sampling rotation of the Great Lakes. In 2012, a range of sampling activities took place in Lake Huron as part of the intensive sampling year, designed to provide data to help address management needs, including efforts to: characterize land use and nutrient loading linkages and the resulting tributary loadings; quantify the magnitude of energy/nutrients shunted along the gradient from nearshore to offshore; understand how energy/nutrients are being allocated between the benthic, mid-depth and pelagic zones of the main basin and the resulting food web structure; better understand how the new nutrient cycle is affecting upper food web production (larval fish - zooplankton interactions, forage fish-predator fish interactions); establish baseline information on the physical (e.g. substrate, bathymetry, littoral cells, sediment transport), chemical, and biological features of the nearshore to guide management actions in the future. Investigative work in 2012 was designed to clarify and quantify how nutrients move through the system and the resulting impact on the food web. We will present an overview of the program as well as an initial assessment of nearshore to offshore remotely sensed chlorophyll for the transects. *Keywords: Lake Huron, Fish management, Food chains.*

WATKINS, J.M.[1], LESHT, B.M.[2], WEIDEL, B.C.[3], RUDSTAM, L.G.[1], CURRIE, W.J.S.[4], STEWART, T.J.[5], JOHNSON, T.B.[5], and BOYER, G.L.[6], [1]Cornell Biological Field Station, 900 Shackelton Pt Rd, Bridgeport, NY, 13030; [2]University of Illinois - Chicago, 845 W Taylor, Chicago, IL, 60607; [3]USGS Lake Ontario Biological Station, 17 Lake St, Oswego, NY, 13126; [4]Dept. of Fisheries and Oceans, 867 Lakeshore Rd, Burlington, ON, L7R 4A6; [5]Ontario Ministry of Natural Resources, Rr #4, Picton, ON, KOK 2T0; [6]SUNY-ESF, Dept. of Chemistry, Syracuse, NY, 13210. **Dynamic Seasonality of Surface Chl and Whiting Events in Lake Ontario Tracked by Remote Sensing and Shipbased Platforms in 2013.**

2013 was a year of intensive sampling in Lake Ontario through the binational Cooperative Science and Monitoring Initiative (CSMI). Several US and Canadian government agencies and universities collaborated to achieve lakewide coverage not seen since the international field sampling years of the 1970s. We use animations of remotely sensed surface

temperature, chl a and remote sensing reflectance (Rrs $_{555}$) to track the seasonality of spring blooms, summer stratification, late summer whiting events, and the fall turnover for 2013. This provides an important context for the variable spatial and temporal extent of our collaborative efforts on several shipbased platforms. Remote sensing observations are nearly continuous in time and space and permit us to scale up to lakewide and growing season estimates. Shipboard measurements provide vital groundtruthing and document biological populations and important subsurface features such as the deep chlorophyll layer. *Keywords: Remote sensing, Spatial analysis, Lake Ontario.*

WATSON, S.B.[1], MATISOFF, G.[2], and GUO, J.[1], [1]Watershed Hydrology and Ecology Research Division, Environment Canada, Burlington, ON, L7R 3A2; [2]Dept. Earth, Environmental and Planetary Sciences, Case Western Reserve University, Cleveland, OH, 44106-7216. **Sediment Influx and Resuspension in Lake Winnipeg.**

There has been a dramatic rise in severe algal blooms in Lake Winnipeg (LW), attributed to increased watershed nutrient inputs, particularly via the Red River. Much of this external loading is associated with suspended particles but the transport and fate of this nutrient fraction within LW and the importance of internal loading via resuspension is unknown. We measured $^{7}$Be, $^{137}$Cs and $^{210}$Pb activities in precipitation, major tributaries and water column suspended matter, in sediment traps and in bottom sediments during the 2012 and 2013 field seasons to estimate the fraction of suspended matter resuspended from the bottom. $^{7}$Be activities and the $^{7}$Be/$^{210}$Pb ratios in sediment trap sediments were higher than in bottom sediments or material from the Red River, indicating that precipitation is a major source of $^{7}$Be to LW. A two-component end-member mixing model using $^{7}$Be/$^{210}$Pb indicates that resuspension of bottom sediment accounted for 79-100% of the suspended material in the water column and in the sediment traps. $^{210}$Pb and $^{137}$Cs activities in sediment cores yield sedimentation rates of 0.029-0.236g/cm$^{2}$/y. Modelled $^{137}$Cs profiles indicate resuspension mixes sediments to depths of 3.7-7 *Keywords: Sediment load, Modeling, Sediment resuspension, Nutrients, Lake Winnipeg.*

WEHRLY, K.E.[1], RISENG, C.M.[2], WANG, L.[3], MASON, L.A.[2], RUTHERFORD, E.S.[4], MCKENNA, JR., J.E.[5], and JOHNSON, L.B.[6], [1]Michigan Department of Natural Resources, Institute for Fisheries Research, Ann Arbor, MI; [2]University of Michigan, Ann Arbor, MI; [3]International Joint Commission, Windsor, ON; [4]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI; [5]USGS Great Lakes Science Center, Cortland, NY;

[6]University of Minnesota-Duluth, Duluth, MN. **Using the Great Lakes Aquatic Habitat Framework (GLAHF) to evaluate ecological indicators developed by the International Joint Commission (IJC).**

The Great Lakes Water Quality Agreement directs the governments of the United States and Canada to restore and maintain the chemical, physical, and biological integrity of the waters of Great Lakes Basin Ecosystem. As such, the International Joint Commission (IJC) has developed 16 apex environmental indicators to assess the current ecological condition of the Great Lakes. These indicators address a variety of concerns including 1) nutrient concentrations and impacts, 2) water quality, toxic chemicals and impacts, 3) ecological integrity, 4) invasive species, 5) habitat, nearshore, and land-margin, and 6) extent, composition and quality of coastal wetlands. Assessment of these indicators requires accessible, compiled, and spatially and temporally intense data. We have assembled a majority of the data needed to integrate, analyze, and display relationships and trends among IJC indicators in a binational geospatial database, the Great Lakes Aquatic Habitat Framework (GLAHF). GLAHF provides the spatial framework for evaluating the status of the Great Lakes based on aquatic and landscape indicators at multiple spatial and temporal resolutions. *Keywords: Indicators, GIS, Great Lakes basin.*

WEISS, L.[1], GHARABAGHI, B.[1], THÉ, J.[2], MATAMALA, F.[2], STAINSBY, E.[3], and WINTER, J.G.[3], [1]University of Guelph, 50 Stone Road E, Guelph, ON, N1G 2W1; [2]Lakes Environmental, 60 Bathurst Drive, Unit 6, Waterloo, ON, N2V 2A9; [3]Ministry of the Environment, 125 Resources Road, Etobicoke, ON, M9P 3V6. **Targeted BMP Scenarios to Control Anthropogenic Sources of Atmospheric Phosphorus Deposition to Lake Simcoe.**

The area surrounding Lake Simcoe has experienced significant population growth and development leading to excessive phosphorus loading. The average annual phosphorus load to Lake Simcoe from atmospheric sources was 17 tonnes during the 2005 to 2009 period, making up 20% of the total phosphorus load to the lake. Lake Simcoe-specific integrated dust emission and deposition models identified various areas within the airshed as 'hot spots' for dust emission. This information allowed the application of Best Management Practices (BMP) to be modeled for those areas. Modeling results suggest that reducing dust emission from the nearshore would significantly reduce overall deposition of phosphorus to the lake. The major sources of dust emission identified within the airshed include unpaved and paved roads, agricultural operations, pits and quarries, and construction activities. BMPs include conservation tillage, cover crops and windbreaks in agricultural areas and watering haul roads and increasing soil moisture on stockpiles at construction sites. This study analyzed PM10 dust emission, transport and deposition modeling results in the context of targeted BMP application scenarios for key anthropogenic local sources within the airshed resulting in an achievable, cost-effective atmospheric phosphorus reduction strategy. *Keywords: Best Management Practices, Eutrophication, PM10 modeling, Deposition, Phosphorus.*

WELLBAND, K.W., PETTITT-WADE, H., FISK, A.T., and HEATH, D.D., Great Lakes Institute for Environmental Research, University of Windsor, 401 Sunset Ave., Windsor, ON, N9B 3P4. **Is Genetic Diversity a Predictor of Invasion Success? A Case Study of Gobies in the Great Lakes.**

Genetic diversity is important for the persistence of species, especially those of conservation concern. Despite this, the importance of genetic diversity to the establishment and persistence of invasive species remains unresolved. In the Great Lakes, round goby is recognized as a successful invader having a high level of genetic diversity but whether this diversity is relevant to the success of the round goby as an invader is unknown. We used a comparative approach to examine whether genetic diversity at microsatellite markers was higher for round goby or tubenose goby, a taxonomically similar but less-successful invasive goby. We provide spatial and temporal comparisons of genetic diversity for central and range-edge populations of gobies to address the significance of genetic diversity to the relative success of invasive gobies. *Keywords: Genetics, Round goby.*

WELLEN, C.C.[1], OSWALD, C.[1], and LONG, T.L.[2], [1]McMaster University, 1280 Main Street West, Hamilton, ON, L8S 4L8; [2]Ontario Ministry of the Environment, 125 Resources Road, Toronto, ON, M9P 3V6. **A Comparison of the Hydrological Controls on Contaminant Export from Urban and Agricultural Watersheds Draining into Hamilton Harbour, Ontario.**

Stormflow contributes elevated fluxes of nutrients and contaminants to aquatic ecosystems. It is unclear whether urban stormflow originates exclusively from impervious surfaces or if there is a significant contribution from pervious surfaces. In this paper, we make use of a 2-year water quality dataset to quantify the sources of stormflow in four watersheds with differing proportions of urban and agricultural land use that drain into Hamilton Harbour, Ontario. We use samples of streamwater (stormflow and baseflow) and historical data on source chemistry (precipitation, runoff from distinct landscape units) to develop an end-member mixing analysis model. This allows us to determine the source contributions of various landuses to stormflow at sub-event timescales. In addition, we use hysteresis patterns in concentration-discharge relationships to examine the timing of runoff contributions from different land use areas to Hamilton Harbour and to examine seasonal variability in flow routing. The results of this study suggest that improvements to our understanding of source water controls on nutrient and contaminant fluxes depend on better spatial and temporal characterization of end-members, particularly in urban-dominated watersheds. *Keywords: Hamilton Harbour, Contaminants, Water quality, End-member mixing analysis, Urban watersheds.*

WELLER, J.D. and CHOW-FRASER, P., McMaster University, 1280 Main Street West, Hamilton, On, L8S 4L8. **Abiotic Changes to Muskellunge Breeding Habitat in Severn Sound, Georgian Bay.**

The muskellunge population in southeastern Georgian Bay appears to be experiencing problems with recruitment. Trophy sized adults are still present in the area but rigorous sampling at historic and suspected nursery sites has failed to find any young-of-the-year muskellunge. A comparison of habitat conditions at historic nursery sites, between 1981 and 2012, indicated that the vegetation and fish communities have changed to a state that may no longer be suitable as muskellunge nursery habitat. These changes to the biotic community have been accompanied by physical changes to the habitat, notably over a decade of sustained low water levels. Here we explore abiotic changes to historic and suspected muskellunge nursery habitat over the last 30 years. Coarse scale modelling of the Severn Sound area coupled with higher resolution, site-specific topographic models suggest that the current low water level conditions have not resulted in a decrease in nearshore habitat area. Further, the duration of the growing season (spawning to fall) does not appear to be limiting. While low water levels have not resulted in a loss of habitat area, we suspect that the sustained nature of the low water conditions could be influencing the observed changes in the vegetative structuring of the habitat that have rendered it unsuitable. *Keywords: Fish management, Coastal wetlands, Georgian Bay.*

WELLS, M.G., COSSU, R., and CHOWDHURY, M., University of Toronto Scarborough, Department of Physical and Environmental Sciences, Toronto, ON, M1C 1A4. **Benthic temperature variation due to large amplitude seiches may impact fish habitat in Lake Simcoe.**

Observations of large amplitude internal seiches in Lake Simcoe, Canada indicate that a large area of the lake bed is potentially subject to high temperature variability. Data were obtained during a 42-day period in late summer with an array of four thermistor chains located in a 5 km line at the depths where the thermocline intersects the shallow slope of the lakebed. The thermocline is located at depths of 12-‼ 14 m during the strongly stratified period of late summer. During periods of strong westerly winds the thermocline is deflected as much as 8 m vertically, so that the location where the thermocline intersects the lakebed strectches over several kilometers. Hence the "wash-zone" of the thermocline is 1/4 of the area of Lake Simcoe, i.e. 170 $km^2$ . This thermocline wash-zone would be most pronounced on the eastern and southern sides of the lake where the lakebed has a very gradual slope. Large lateral movements of the thermocline lead to rapid changes in the benthic temperature, which could increase the thermal stress upon fishes and benthic organisms. Our findings suggest that these infrequent events may have a strong role in controlling the cold water and cool water fish populations. We discuss the potential biological response of aquatic organisms to these ubiquitous thermal fluctuations. *Keywords: Water currents, Lake Simcoe, Fish behavior.*

WHEELER, R.L.[1], HOKANSON, A.[2], and UZARSKI, D.G.[1], [1]Institute for Great Lakes Research, CMU Biological Station, Department of Biology, Central Michigan University, Brooks 127, Mount Pleasant, MI, 48859; [2]Water Resources Division, Michigan Dept. of Environmental Quality, 525 W. Allegan St., Lansing, MI, 48933. **Status and Trends of Michigan Great Lakes Coastal Wetlands Over a Three Year Period and a Comparison of Ecosystem Indicator Performance.**

Ecosystem indicators have been developed to monitor status and trends of the health of Great Lakes coastal wetlands. The Great Lakes Coastal Wetland Monitoring Plan (GLCWMP), developed by the Great Lakes Coastal Wetland Consortium (GLCWC), and the Michigan Rapid Assessment Method (MiRAM) for wetlands, developed by the Michigan Department of Environmental Quality - Water Resources Division, are two such methods that have been used to evaluate these systems. However, the GLCWC plan was developed specifically for Great Lakes coastal wetlands and the MiRAM was developed for use within all Michigan wetlands. These methods were simultaneously implemented over a three-year period in order to evaluate Great Lakes coastal wetlands and compare the results of each indicator. The overall objectives of this study were to visit sites annually to collect physical-chemical, plant, macroinvertebrate, and fish data, report on annual status and trends using GLCWC IBIs relative to past (baseline) data, and to compare these results with the findings of the MiRAM. Our results suggest differences and similarities in the performance of each indicator, which will allow for continued development of these tools. *Keywords: Bioindicators, Great Lakes coastal wetlands, Ecosystem health, Wetlands.*

WHITEHEAD, B.[1], SHEN, L.[1], and STAPLES, J.B.[2], [1]Ontario Ministry of the Environment, 125 Resources Road, Etobicoke, ON, M9P 3V6; [2]Ontario Ministry of Natural Resources, 300 Water Street, Peterborough, ON, K9J 8M5. **Estimating Ontario's Water Withdrawals and Consumption in the Great Lakes Basin.**

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, water takings are governed by the Ontario Water Resources Act and the Water Taking Regulation 387/04. Section 34 of the Act requires anyone taking more than 50,000 litres of water a day, with some limited exceptions, to obtain a Permit to Take Water. Major changes to the Permit to Take Water Program took effect on January 1, 2005, including strengthening the factors to be considered by the province when assessing water taking applications, and requiring monitoring and reporting of water takings by all permit holders. An internet based Water Taking Reporting System (WTRS) allows permit holders to submit their water taking data electronically. To support improved regional estimates and reporting of water withdrawals and consumption, a methodology was recently developed and tested that incorporates WTRS data and revised consumption coefficients into annual data submissions. *Keywords: Great Lakes basin, Hydrologic budget, Data acquisition.*

WHITTEN, A.L. and MCNAUGHT, A.S., Central Michigan University, 1200 S. Franklin St., Mount Pleasant, MI, 48859. **The Effects of Dreissenids on Zooplankton Community Composition and Size Structure.**

Mainly known for ingesting phytoplankton, dreissenid mussels can also consume small-bodied zooplankton within their siphon size range. This study looks at how dreissenids affect the composition of zooplankton communities through their size-selective feeding and feeding capacity. In summer 2013, a mesocosm experiment, simulating Lake Michigan, was conducted for 7 days to measure dreissenid density effects on zooplankton community composition and size-structure. Zooplankton subsamples were collected daily with a 10-cm diameter, 68-µm mesh net and preserved with sugar formalin. Planktonic species were enumerated using a compound microscope (100x), and size structure was measured using FlowCAM® digital imaging. A size spectrum (linear regression between Ln abundance and Ln body mass) was constructed for each sample to observe community changes over time and across dreissenid density. Abundance of all taxa except some rotifers declined throughout the experiment, especially in high density dreissenid treatments. The midpoint height of

size spectra also decreased with increasing mussel density. Size-spectrum slope did not change in a consistent manner over time and across dreissenid densities. Thus, dreissenid density does not have a steady effect on all components of zooplankton communities. *Key-words: Invasive species, Dreissena, Zooplankton.*

WIJESINGHE, R.U.[1], OSTER, R.J.[1], HAACK, S.K.[1], FOGARTY, L.R.[1], TUCKER, T.R.[2], and RILEY, S.C.[2], [1]U.S. Geological Survey, Michigan Water Science Center, 6520 Mercantile Way, Suite 5, Lansing, MI, 48911; [2]U.S. Geological Survey, Great Lakes Science Center, 1451 Green Rd, Ann Arbor, MI, 48105. **Detection and quantification of *Clostridium botulinum* type E toxin gene (*bontE*) in *Cladophora*, sediment and water at the Great Lakes beaches.**

*Clostridium botulinum* type E toxin is responsible for the death of thousands of birds and fish in the Great Lakes. Previous studies have suggested that algae may support the survival and persistence of *Clostridium* species. This study was conducted to determine the occurrence of *C. botulinum* type E at 10 beaches found along lakes Michigan, Erie, Superior and Huron in five states. Algae (150), sediment (74) and water (37) samples were analyzed from June to November 2012. Quantitative polymerase chain reaction (qPCR) was used to quantify the type E toxin producing *bont*E gene of *C. botulinum*. This study found that *C. botulinum* is ubiquitous, but its distribution is consistent across neither location nor matrices. *Bont*E was detected most frequently at Jeorse Park and Portage Lakefront Beaches at Lake Michigan and Bay City State Park Beach at Lake Huron. *BontE* concentration in algae was significantly higher than the other two matrices ($P<0.05$). The results of this study suggest that algal mats provide a better micro environment for the growth of *C. botulinum* than other matrices. Ultimately, quantitative assessment of *bont*E gene is important for understanding the distribution of these bacteria in different matrices and different geographical locations *Key-words: Environmental health, Clostridium botulinum, Algae, Microbiological studies.*

WILLINK, P.W., Shedd Aquarium, 1200 South Lake Shore Drive, Chicago, IL, 60605. **Mottled Sculpin *Cottus bairdii* in Illinois; A Motley Tale of Subspecies, Invasive Species, Habitat Degradation, and Climate Change.**

There has been discussion that Mottled Sculpin *Cottus bairdii* in the Great Lakes can be divided into two subspecies, the Northern Mottled Sculpin *Cottus bairdii bairdii* and the Great Lakes Mottled Sculpin *Cottus bairdii kumlieni*. The distinction is based on lateral pores and caudal peduncle proportions, but there is not 100% agreement among ichthyologists concerning the validity of this taxonomy. In Illinois, the Great Lakes Mottled Sculpin is restricted to nearshore Lake Michigan. The Northern Mottled Sculpin is found in the Des Plaines and Fox drainages. Mottled Sculpin have not been found along the Illinois shoreline of Lake Michigan for over a decade, and it is believed that the invasive Round Goby *Neogobius melanostomus* is responsible for the dramatic decline. The Des Plaines River population is declining due to habitat loss. The Fox River population is stable, but climate modeling is predicting declines in the future. Regardless of ones opinions about subspecies, Mottled Sculpin management in Illinois requires the recognition of different Operational Taxonomic Units and the distinct threats they face. *Keywords: Round goby, Mottled sculpin, Climate change, Habitat loss, Invasive species, Taxonomy.*

WILLS, T.[1], JOHNSON, J.E.[2], THOMAS, M.V.[1], FIELDER, D.G.[2], and ZELLINGER, J.[1], [1]Michigan Department Natural Resources, Lake St. Clair Fisheries Research Station, Mt. Clemens, MI; [2]Michigan Department Natural Resources, Alpena Fisheries Research Station, Alpena, MI. **Does "Nearshore Phosphorus Shunt" Translate to Higher Abundance of Nearshore Fish?**

Invasive dreissenid mussels and round gobies are thought to redirect energy flow from the pelagic to benthic zone and from offshore to nearshore, an outcome commonly referred to as nearshore/benthic shunt (NBS). Nutrients from tributaries are likewise subject to NBS. To test the hypothesis that NBS fuels heightened fish production in the nearshore we sampled two bays with differing tributary nutrient loading rates and one nearshore site with no tributary. Fish catch rates were lowest at Thunder Bay, the site with lower nutrient loading and highest at Saginaw Bay, where loading was highest, but both exhibited declines over time. Thunder Bay's catch rates declined since NBS and were lower than the site with no tributary. Walleye were evident in all areas but other research suggests walleye biomass has declined since NBS. Our findings indicate NBS is not translating into greater fish abundance, and productivity remains sequestered in forms not readily available to the fish community, such as driessenids and Cladophora spp. Fish population indices were highest in proximity to the Saginaw River but there was no discernable benefit of proximity to the less productive Thunder Bay River. The effects of NBS were evidently detrimental to productivity of these nearshore fish communities. *Keywords: Invasive species, Food chains, Fish.*

WILSON, C.C.[1], WOZNEY, K.M.[1], and LISKAUSKAS, A.P.[2], [1]Ontario Ministry of Natural Resources, Trent University, Peterborough, ON, K9J 7B8; [2]Ontario Ministry of Natural Re-

sources, 1450 Seventh Avenue East, Owen Sound, ON. **Genetic assessment of muskellunge rehabilitation efforts in Lake Huron and Lake Simcoe.**

The pronounced geographic and genetic structuring among muskellunge populations in Lake Huron and eastern Ontario enables identification of source populations for rehabilitation and restoration efforts, as well as tracking the relative contributions and fitness of contributing populations and stocking efforts. Using microsatellite genotyping, we assessed the effectiveness of efforts to re-establish extirpated muskellunge populations in the Spanish River (Lake Huron North Channel) and Lake Simcoe. For the Spanish River effort, genetic data from source populations were used as baseline data to resolve the source(s) and parental ancestry of wild-caught juveniles, as well as to evaluate the success of stocking efforts. For Lake Simcoe, the ancestral origins of the extirpated population were uncertain, leading to debate over whether Great Lakes or inland populations were the most appropriate sources. Analysis of DNA from historical (archival) scale samples showed that the historical population was more closely related to Kawartha Lakes (inland) than Great Lakes muskellunge, and that a remnant population is still present in neighbouring Lake Couchiching. Despite this, stocking from Great Lakes sources may ultimately be most successful, due to altered ecological conditions in Lake Simcoe from the past to the present. *Keywords: Fish populations, Remediation, Conservation.*

WILSON, M.C.[1], BOEGMAN, L.[1], SHORE, J.A.[2], and RAO, Y.R.[3], [1]Queen's University, Department of Civil Engineering, 58 University Avenue, Kingston, ON, K7L 3N6; [2]RMC, Department of Physics, Royal Military College of Canada, PO Box 17000, Station Forces, Kingston, ON, K&K 7B4; [3]Environment Canada, Canada Centre for Inland Waters, 867 Lakeshore Road, Burlington, ON, L7R4A6. **Wind-Forced Dynamics of the Lake Ontario North Shore Coastal Boundary Layer.**

Data collected from Lake Ontario near Port Hope during the summer of 2010 are investigated to understand the wind-forced dynamics of the coastal boundary layer. The temperature and velocity structure are observed along a shore-perpendicular mooring transect and turbulent dissipation and backscatter (a proxy for sediment re-suspension) are measured from a bottom tripod. The magnitude of, and time lag between, dependent physical processes show that the wind on the surface of the lake initiates pressure gradients that are perpendicular to the imposed stress. When pressure gradients are large, the position of the thermocline-shelf intersection responds quickly and, given the relatively shallow slope of the lake-bed, upwelling and downwelling events cause large lateral thermocline excursions. In Lake Ontario, the prevailing winds are from the southwest which results in a positive offshore pressure gradient and upwelling behaviour. We also investigate the effect of the cross-slope thermocline motions on vertical mixing, energy dissipation and sediment re-suspension. *Keywords: Lake Ontario, Hydrodynamics.*

WINTER, J.G., PALMER, M.E., HOWELL, E.T., and YOUNG, J.D., Ontario Ministry of the Environment, 125 Resources Road, Toronto, ON, M9P 3V6. **Long term changes in nutrients, chloride and phytoplankton in the nearshore waters of Lake Erie.**

The objective of our intakes monitoring programme is to monitor and assess the water quality of the Laurentian Great Lakes nearshore areas and connecting channels, using municipal water treatment plant intakes as collection points. To date we've found that annual average chlorophyll concentrations and phytoplankton densities decreased significantly ($P < 0.05$) at stations in Lakes Erie and Ontario in relation to nutrient load reductions during the early 1980s. There were further notable decreases following the invasion of the lakes by dreissenid mussels during the late 1980s to mid-1990s. The greatest rates of decrease were in diatom abundance. Abundances have shown an increasing trend since the 1990s however (although at lower levels), particularly in the western and central basins of Lake Erie. In this presentation, we focus on 3 of the intakes on Lake Erie, one in each basin. We assess trends in annual average concentrations of total P, silica, nitrate, total nitrogen, chloride, chlorophyll and algal cell densities, investigate changes in major algal groups, and investigate changes in seasonality and community composition of the phytoplankton. *Keywords: Eutrophication, Water quality, Dreissena, Phytoplankton.*

WOLF, A.T. and HOWE, R.W., Cofrin Center for Biodiversity, Department of Natural and Applied Sciences, University of Wisconsin-Green Bay, Green Bay, WI, 54311-7001. **Management of a Dynamic Coastal Ecosystem: The Point au Sable Nature Preserve in Lower Green Bay, Wisconsin.**

Coastal habitats are dynamic by nature, creating management challenges that differ significantly from those of more stable or predictable environments like forests and even inland wetlands. We use historical maps and air photos to illustrate a century of ecological dynamics at Point au Sable, a coastal natural area on the eastern shore of Green Bay. Changes in Lake Michigan water levels have dramatically affected the configuration of woodland, wetland, and estuarine habitats at Point au Sable. Superimposed on these changes have been the arrivals of invasive species like Phragmites australis and dreisennid mussels, creating new challenges for managing coastal wetlands and shoreline habitats. Although long

term changes in this system are inevitable, we argue that proactive management is necessary to preserve reservoirs of species that comprise the local ecological mosaic. *Keywords: Invasive species, Green Bay, Habitats.*

WOOD, N.J., GEHRING, T.M., and HEUMANN, B.W., Central Michigan University, Mount Pleasant, MI, 48859. **Analysis of invasive mute swan impacts on submerged aquatic vegetation in coastal wetlands using remote sensing techniques.**

Mute swans (*Cygnus odor*) are an invasive species to the coastal wetlands of Michigan. Submerged aquatic vegetation (SAV) is the preferred food of the mute swan and their herbivory of SAV is an excellent way to track the damage mute swans cause to the coastal wetlands. Previous studies have used direct sampling of SAV beds to track this damage, but it is a small scale, time and labor intensive methodology. Remote sensing may provide a way to track entire SAV beds and the impacts mute swans have on them in larger spatial and temporal scales with less effort. This analysis uses imagery of drowned river mouth lakes on the eastern shore of Lake Michigan from the past 30 years and correlates the amount of SAV with mute swan population counts occurring during the same time period. The results of the analysis are expected to show a negative relationship with mute swan numbers and the area of SAV. This project will hopefully open a new avenue for studying the invasive mute swan and the impacts they have in the coastal wetlands of Michigan. *Keywords: Invasive species, Avian ecology, Remote sensing.*

WU, C.H.[1], LIU, L.[1], and ANDERSON, E.J.[2], [1]University of Wisconsin-Madison, Dept. of Civil and Environmental Engineering, 1415 Engineering Drive, Madison, WI, 53706; [2]Great Lakes Environmental Research Laboratory, 4840 S. State Rd., Ann Arbor, MI, 48108. **Meteorologically induced high-frequency water level oscillations in Lake Michigan.**

High-frequency water level oscillations (HFWLOs) driven by meteorological forcings are frequently observed in Lake Michigan. To obtain a better understanding of generation mechanisms and propagation of these HFWLOs, meteorological data and water levels at in the Manistique River Bay were examined. The observations show that both barometric pressure disturbance and wind variation associated with storms are the drivers of the HFWLOs. Three different types of disturbance were observed: barometric pressure jumps; barometric pressure gradients and wind variations; and the combination of the two. Three components of HFWLOs were distinguished in response to the different types of disturbance: long waves in a wide frequency band with period from a few minutes to 1 h were excited by the passage of barometric pressure jumps; higher order normal modes of seiches in the same frequency band with period between 1 h and 2 h were generated by wind variations; and edge waves with period less than 20 min were driven by wind variations and barometric pressure gradients. The meteorologically induced long waves were amplified due to Proudman resonance and shoaling; and the waves were further magnified due to harbor resonance. *Keywords: Waves, Water level fluctuations, Lake Michigan.*

# X

XIA, M.[1], NIU, Q.[1], JIANG, L.[1], CAO, Z.[1], RUTHERFORD, E.S.[2], SCHWAB, D.J.[3], PANGLE, K.[4], LUDSIN, S.A.[5], MASON, D.M.[2], ANDERSON, E.J.[2], and MARIN, J.[4], [1]University of Maryland Eastern Shore, Department of Natural Sciences, Princess Anne, MD, 21853; [2]NOAA Great Lakes Environmental Research Lab, 4840 S. State Rd, Ann Arbor, MI, 48108; [3]University of Michigan, Graham Environmental Sustainability Institute, 625 E. Liberty St, Ann Arbor, MI, 48104; [4]Department of Biology, Central Michigan University, Mount Pleasant, MI, 48859; [5]Department of Evolution, Ecology, and Organismal Biology, the Ohio State University, Columbus, OH, 43212. **The application of an unstructured based bio-physical model to Lake Erie.**

Yellow perch (Perca flavescens; YP) is an economically and ecologically important species across the Great Lakes, which demonstrates variable recruitment to the fishery that we hypothesize is regulated by physical processes. To help understand the recruitment, a coupled biophysical model was built to better hindercast/forecast the hydrodynamics and water quality in western Lake Erie. An extant three-dimensional, wave-current, coupled Finite Volume Coastal Ocean Model (FVCOM) was used to simulate water movement in Lake Erie, particularly the western Lake Erie. In additional, we also present the improved water quality model and theirs application. We will evaluate the interactive effects of river discharge and wind-driven currents on the plume and nutrient, phytoplankton and zooplankton distribution which are important to the creation and expansion of high-quality nursery habitat. The Erie model is also coupled with wave model or FVCOM-SWAVE to simulate the effect of waves on nearshore circulation and velocity fluctuations. The effect of wave to the nutrient/zooplankton dynamics is further investigated. We also calibrate and validate the model using physical (e.g., temperature, water clarity, currents) and biological (e.g., zooplankton, nutrient) data collected in western Lake Erie. *Keywords: Coastal ecosystems, Hydrodynamic model, Zooplankton.*

XIA, X., CRIMMINS, B.S., HOPKE, P.K., and HOLSEN, T.M., Clarkson University, Potsdam, NY. **The Analysis of Synthetic Musks using an In-cell clean-up and Atmospheric Pressure Gas Chromatography - Mass Spectrometry.**

The ubiquitous nature of synthetic musks present significant analytical challenges for analytical chemists. To circumvent these challenges we have developed an in-cell cleanup procedure using a Dionex Accelerated Solvent Extractor using Florisil as a lipid retainer. The current method minimizes sample exposure to ambient air and musk background contamination. The concentrated extracts are then analyzed using an Atmospheric Pressure Gas Chromatograph - Quadrupole Time of Flight Mass Spectrometer. The current paper will outline the method development of this technique including, sensitivity and background, and applicability of this method to measure this class of emerging contaminants in Great Lakes lake trout. *Keywords: Chemical analysis, Environmental contaminants, Organic compounds.*

XIAO, C.[1] and LOFGREN, B.M.[2], [1]Cooperative Institute for Limnology and Ecosystems Research, University of Michigan, 4840 S. State Rd., Ann Arbor, MI, 48108; [2]NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Rd., Ann Arbor, MI, 48108. **A Study of Great Lakes Effects on Cold Season Synoptic Processes Using WRF Comparison Experiments.**

Two synoptic events in late 2013 are studied with regard to the Great Lakes' effects on low system development by using the latest Weather Research and Forecast (WRF) Model. The first case is a deep low (DL) from 16 Nov to 18 Nov, corresponding to a Midwestern tornado outbreak; the second is a shallow low (SL) from 13 Dec to 15 Dec, corresponding to a broad-ranging snowfall in the Northeastern America. For the two processes, the community Noah Land Surface Model in WRF is initialized in three different configurations: the control runs with real MODIS land use, the no-lakes runs in which the lakes are replaced by terrestrial land use, and the SST-lakes runs using high-resolution sea surface temperature analysis. For the control runs, the WRF model exhibits a good performance in simulating the synoptic scale weather processes, for both the DL and SL. Comparisons between control runs and no-lakes runs show that the Great Lakes generally strengthen the low system near the surface. This process brings more precipitation in the near-lake region and constrains the precipitation in the off-lake area. The lake effect becomes much more significant for the development of SL and associated precipitation. Meanwhile, the circulation and precipitation reveal less sensitivity to the varying SST, compared with the modified land use. *Keywords: Atmosphere-lake interaction, Great Lake effects, Model studies, Atmospheric circulation.*

XU, W.[1], MINSKER, B.S.[1], COLLINGSWORTH, P.[2], and BAILEY, B.A.[3], [1]Department of Civil and Environmental Engineering, University of Illinois at Urbana-Champaign, Urbana, IL, 61801; [2]U.S. Environmental Protection Agency, Great Lakes National Program Office, Chicago, IL, 60604; [3]Department of Mathematics and Statistics, San Diego State University, San Diego, CA, 92182. **Spatial Pattern of Great Lakes Estuary Processes from Water Quality Sensing and Geostatistical Methods.**

Mixing of river and lake water can alter water temperature, conductivity and other properties that influence ecological processes in freshwater estuaries of the Great Lakes. This study aims to develop geostatistical methods for rapidly visualizing and understanding sampling results and enabling adaptive sampling to explore interesting phenomena in more detail. A towed undulating sensor package, called Triaxus, was used for collecting various physical and biological water quality in three estuary areas of Lake Michigan in Summer 2011. Several geostatistical methods and visualizations are explored on the data to gain insights on water quality processes. Local G statistics identify hotspots and coldspots in water chemistry across the estuaries, including locations of water intrusion. To further understand the interactions and differences between river and lake water, K-means clustering algorithm is used to spatially cluster the water based on temperature and specific conductivity. Statistical analysis indicates that clusters with significant river water can be identified from higher turbidity, specific conductivity, and Chlorophyll concentrations. Zooplankton features are also different in each cluster. It also indicates that dissolved oxygen levels are more positively correlated with Chlorophyll concentrations in the deeper lake. *Keywords: Spatial analysis, Monitoring, Estuaries.*

XUE, P.[1], HU, S.[2], and SCHWAB, D.J.[3], [1]Michigan Technological University, 1400 Townsend Dr., Houghton, MI, 49931; [2]International Center for Marine Studies, Shanghai Ocean University, 999 Hucheng Huan Rd., Shanghai, 201306, China; [3]Michigan Tech Research Institute, Michigan Technological University, Ann Arbor, MI, 48105. **Response of Lake Superior to the mesoscale meteorological forcing.**

Hydrodynamic models for Lake Superior are all facing the challenges of improving the accuracy of simulating its circulation pattern and thermal structure, which have been suggested by several studies to be very sensitive to the meteorological forcing. In this study, we developed a large-scale high-resolution Weather Research and Forecasting (WRF) Model and a 3-D Lake Superior model with an aim to understand the dynamical response of the lake to the mesoscale meteorological forcing. The WRF model is configured with three nested domains with horizontal resolutions of 36, 12, 4 km, respectively, constrained by lateral

boundary condition from ERA40. Lake simulations driven by surface forcings 1) predicted by WRF and 2) generated from traditional interpolation from in situ data collected from surface meteorological stations and moored meteorological buoys are compared and analyzed. The impact of the mesoscale variability of surfacing forcings on the circulation pattern, thermal structure, wave energy distribution and water level are discussed. *Keywords: Hydrodynamic model, Hydrodynamics, Atmosphere-lake interaction.*

# Y

YAGI, K. and GREEN, D.M., Redpath Museum, McGill University, Montreal, QC, H3A 0C4. **Mitigating the adverse effect of invasive common reeds, *Phragmites australis*, on the survival of Fowler's Toads, *Anaxyrus fowleri*, at Long Point, Ontario.**

At Long Point, Ontario, on the north shore of Lake Erie invasive common reeds, *Phragmites australis*, have spread throughout the marshland areas used by Fowler's Toad, *Anaxyrus fowleri*, for breeding. Since 1995, when they were first noted in the area, extent of the reeds has expanded at a rate of about 11% (six hectares) per year in the Crown Marsh area at the base of Long Point. Based on the results of long-term study in an 8 km wide study area at the western end of Long Point, the toad population demonstrated density-dependent growth from 1989 through 2002. After 2002, however, the spread of the reeds and consequent loss of toad breeding habitat resulted in progressive population decline in the toads associated with reduced reproduction, despite a lack of significant loss of adult habitat. The population of adult Fowler's Toads declined from a peak, pre-*Phragmites*, abundance of over 600 individuals in the early 1990's to only 30 individuals in 2013. To alleviate this decline and attempt to recover the Fowler's Toad population at Long Point, experimental breeding ponds for toads were dug in early 2013. Toads have been successfully raised in these ponds. The ponds show promise as a means of managing for certain wildlife even where *Phragmites* removal may be intractable. *Keywords: Phragmites australis, Amphibians, Conservation.*

YANG, W.[1], LIU, Y.B.[1], SIMMONS, E.J.[1], and MCKAGUE, K.[2], [1]Department of Geography, University of Guelph, 50 Stone Road E., Guelph, ON, N1L 0E3; [2]Ontario Ministry of Agriculture and Food, Environmental Management Branch, Woodstock Resource Ctr Unit A, 401 Lakeview Dr, Woodstock, ON, N4T 1W2. **Evaluating BMP Effectiveness at**

**Field and Watershed Scales in the Gully Creek Watershed of Lake Huron Basin Using SWAT.**

During 2010-2013, Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) established the Watershed Based BMP Evaluation (WBBE) program and the 15-km2 Gully Creek watershed of Lake Huron Basin was selected as one of the two study sites to conduct BMP experiment, monitoring, and modelling. In the project, the Soil and Water Assessment Tool (SWAT) was adapted to examine the effectiveness of conservation tillage, nutrient management, cover cropping, and Water and Sediment Control Basin (WASCoB) BMPs at field and watershed scales. The modelling shows that of the three land management BMPs, conservation tillage, cover crop, and nutrient management rank from high to low in terms of effectiveness in reducing sediment and TP loads to the Lake Huron. The effectiveness of WASCoBs is comparable to conservation tillage and cover cropping and is somewhat effective in reducing both particulate and dissolved nutrients. At field scale, the four BMPs exhibit clear spatial patterns in terms of their effectiveness in reducing sediment and nutrient loadings. Typically, land management BMP implementation in the upper portion of the watershed is more effective. The WASCoBs are more effective in sediment and nutrient reduction downstream of the channel network due to their cumulative impacts on water flow in downstream drainage ways. *Keywords: Agricultural Best Management Practicess, Water quality, SWAT, Model studies, Lake Huron, Field and watershed scales.*

YONGABO, P.Y.[1] and NYINAWAMWIZA, L.N.[2], [1]University of Rwanda-College of Science and Technology, University of Rwanda-College of Agriculture,Animal Sciences and Vetrinary Medicine, HUye, SP, 117, Rwanda; [2]Musanze, Musanze, NP, 210, Rwanda. **Lake Kivu fisheries ground mapping, Rwandan side.**

This study aimed at mapping out the fisheries ground of the lake as the spatial distribution of fisheries operating units were not known and fisheries management structure were not well understood, the study coved 5 Rwandan basins (Rubavu, Rutsiro, Karongi, Nyamasheke and Rusizi). The participatory GIS approach has been used for identifying embarkation and debarkation sites, field surveys also have been done for the same purpose. Interpolations have been done for showing the link between sites and trimarans abundances. 59 sites have been identified covering 1015 Km2 of the Rwandan side, among the 5 basins, Nyamasheke has been identified to have the highest number of sites (29 sites) and Rubavu with the lowest (4 sites). There is a high variation between trimaran density per sites with the maximum of 14/1 in Rusizi basin and the minimum of 3/1 in Rutsiro and Karongi, the overall average density of the lake is 6/1. The site water surface coverage average is 17km2, and the smallest coverage is observed in Rusizi (4Km2) and the biggest in Rutsiro (55 Km2). With the fisheries ground mapping a sp *Keywords: Fisheries, Fish, Monitoring.*

YOUNG, J.D.[1], WINTER, J.G.[1], PALMER, M.E.[1], DOLSON, R.[2], EVANS, D.O.[3], DUNLOP, E.S.[3], GINN, B.K.[4], RENNIE, M.D.[5], and KELLY, N.E.[6], [1]Ontario Ministry of the Environment, Biomonitoring Section, Toronto, ON, M9P 3V6; [2]Ontario Ministry of Natural Resources, Biodiversity and Monitoring Section, Sutton, ON, L0E 1R0; [3]Ontario Ministry of Natural Resources, Aquatic Research and Monitoring Section, Peterborough, ON, K9J 7B8; [4]Lake Simcoe Region Conservation Authority, Environmental and Science Monitoring, Newmarket, ON, L3Y 4X1; [5]Fisheries and Oceans Canada, Freshwater Institute, Winnipeg, MB, R3T 2N6; [6]York University, Faculty of Environmental Studies, Toronto, ON, M3J 1P3. **A Comprehensive Review of the State of Lake Simcoe.**

The Lake Simcoe ecosystem has experienced many changes over the past two centuries. Signs of stress in the lake became apparent in the 1970s, when high nutrient loads led to low dissolved oxygen and cold-water fish recruitment failure. In the 1980s, programs were initiated for reducing nutrient loading and monitoring water quality and aquatic life. While remedial efforts resulted in improvements to nutrient loads and dissolved oxygen, further changes to Lake Simcoe added stress to the aquatic ecosystem. For example, warming air temperature increased the duration of stratification and reduced the period of ice cover, and the spiny water flea, dreissenids and round goby, among others, became established in 1994, 1996 and 2010, respectively. Additionally, increases in cations and chloride, possibly associated with road salt, have been observed. These changes likely have had interactive effects on the aquatic communities (i.e., benthic invertebrates, phytoplankton, zooplankton, and warm- and cold-water fish), which have also changed considerably. In this presentation, we provide an overview of Lake Simcoe by presenting long-term monitoring results of both stressors and aquatic responses, highlighting research that helps interpret these trends, and discussing the results in the context of possible multiple stressor interactions. *Keywords: Lake Simcoe, Multiple stressors, Indicators.*

YOUSEF, F.[1], SHUCHMAN, R.A.[2], FAHNENSTIEL, G.L.[2], and SAYERS, M.[2], [1]Michigan Technological University, 1400 Townsend Dr., Houghton, MI, 49931; [2]Michigan Tech Research Institute, 3600 Green Ct., Ste. 100, Ann Arbor, MI, 48105. **Satellite Observations of Long Term Trends in Optical Properties of the Upper Great Lakes.**

Satellite retrievals of water attenuation (kd), Photosynthetically Active radiation (PAR) and photic depth were used to characterize water clarity of the upper Great Lakes. Using a combination of SeaWiFS and MODIS ocean color satellite data, time series estimates of Kd, PAR and photic depth have been made from 1998 to the present for Lakes Superior, Michigan and Huron on a 1 km grid throughout these three upper Laurentian Great Lakes. The time series provided insights into geospatial changes in Great lakes water clarity that were the result of introduction of invasive species, nutrient loading and climate change. The satellite water clarity retrievals compare favorably to in situ optical measurements collected near coincidentally to the satellite overpasses from research vessels, and document the dramatic increases in water clarity, as a result of the introduction of invasive mussels in lakes Michigan and Huron. The time series in Lake Superior, which is the least affected Lake in respect to anthropogenic forcing, exhibited little change in water clarity over the fifteen year observation period. *Keywords: Remote sensing, Water clarity, Productivity, Water quality.*

YUILLE, M.J. and JOHNSON, T.B., Ontario Ministry of Natural Resources, Glenora Fisheries Station, 41 Hatchery Lane, Picton, ON, K0K 2T0. **Shocking Results: A Novel Approach to Estimating Round Goby Densities in Lake Ontario.**

Since their discovery in 1998, round goby (*Neogobius melanostomus*) have become a dominant component of the Lake Ontario nearshore fish community. This study uses a novel approach to estimate round goby abundance across a gradient of depths and substrates using an underwater electrofisher and camera. We found round goby abundance was negatively correlated with depth and was comparable to estimates from index trawling programs. Controlled experiments showed that the underwater electrofisher was more effective on sand than cobble substrate (ANOVA, $p < 0.01$), but was only able to identify 30% of round goby present. Furthermore, advances in technology have increased underwater video picture resolution. A side-by-side comparison of our original camera and a high definition camera showed the high definition underwater camera to be more effective at identifying round goby in shallow complex substrate (ANOVA, $p <0.01$). Both cameras performed equally at our deeper sites. This study suggests that index trawling programs are under representing the true abundance of round goby and their biomass may contribute substantially more to the Lake Ontario ecosystem than once suspected. *Keywords: Round goby, Deep water electrofishing camera, Assessments, Lake Ontario.*

# Z

ZANCHETTA, C.V.[1], MOORE, D.J.[2], QUINN, J.S.[3], and WESELOH, D.V.C.[4], [1]1Biology Department, McMaster University, 1280 Main Street West, Hamilton, ON, L8S 4L8; [2]Bird Studies Canada, 115 Front Street, Port Rowan, ON, N0A 1A0; [3]Canadian Wildlife Service-Ontario Region, 867 Lakeshore Road, Burlington, ON, L7R 4A6; [4]Canadian Wildlife Service-Ontario Region, 4905 Dufferin Street, Downsview, ON, M3H 5T4. **Population trends of colonial waterbirds nesting in Hamilton Harbour in relation to habitat creation and management.**

Since 1975, the diversity and numbers of colonial waterbirds breeding in Hamilton Harbour have increased. Population targets for the six nesting species were set in 1992 and reassessed in 2012. Population trends were assessed for the period since a harbour-wide waterbird management program was implemented. Three species exhibited increasing or stable population trends (1997-2013): Double-crested Cormorants (Phalacrocorax auritus; decelerating trend, exceeding target of 2,500 nests); Caspian Terns (Hydroprogne caspia; within 400-600 nest target); and Black-crowned Night-Herons (Nycticorax nycticorax; inverse U trend, within 100-200 target). Despite conservation efforts, Herring Gulls (Larus argentatus) and Common Terns (Sterna hirundo) underwent marked declines, although both are currently within targets (200-300 and 300-600 nests, respectively). Ring-billed Gulls (L. delawarensis) were successfully reduced from 23,590 to 11,133 nests, but still exceed the target (<10,000 nests). Three wildlife islands constructed in 1996 have been successfully colonized, although inter-specific competition requires annual management to maintain diversity. Population trends will be assessed in relation to changes in habitat availability and management effort within the harbour and recommendations for future management will be made. *Keywords: Hamilton Harbour, Waterbird, Populations, Trends, Management, Targets.*

ZHOU, Y.[1], BELETSKY, D.[2], RICHARDS, R.P.[3], RAO, Y.R.[4], HO, J.C.[1], and MICHALAK, A.M.[1], [1]Department of Global Ecology, Carnegie Institution for Science, Stanford, CA, 94305; [2]Cooperative Institute for Limnology and Ecosystems Research, School of Natural Resources & Enviro, Ann Arbor, MI, 48109; [3]National Center for Water Quality Research, Heidelberg University, Tiffin, OH, 44883; [4]Water Science & Technology, Environment Canada, Builington, ON, L7R 4A6. **A statistical model of the interannual variability of hypoxia in Lake Erie.**

Hypoxia (low dissolved oxygen) has been observed in the central basin of Lake Erie for many years, but the impact of various controlling factors is poorly understood. Understanding and predicting its seasonal and interannual variability is important for assessing its impacts, reducing its extent, and guiding management decisions. Since the mid-1980s, dissolved oxygen data have been collected from cruise-based synoptic surveys lasting less than a week multiple times during the summer. Based on these measurements from all the available cruises, we have developed geostatistical data fusion approaches to produce an accurate estimate of the spatial extent of the hypoxic region and associated uncertainties in Lake Erie over the last two decades. The purpose of this work is to explore the combined effects of nutrient loading together with other factors such as wind and precipitation to explain the interannual variation of hypoxic extent. Our results suggest that soluble reactive phosphorous loading, river discharge, wind stress, directional wind duration and precipitation all affect the variability of hypoxic extent. The best combination of these variables explains more than 80% of this variability. We found that the 2012 North American drought directly contributed to a record-breaking hypoxic event in Lake Erie. *Keywords: Lake Erie, Hypoxia, Oxygen, Statistics, Water quality.*

ZIELINSKI, B.S., Biological Sciences & Great Lakes Institute for Environmental Research, University of Windsor, Windsor, On, N9B 3P4. **The scent of a man (Neogobius melanostomus).**

Metabolites released by conspecifics often serve as attractants during reproduction. This strategy is likely utilized by the round goby, a highly successful invasive species in the Great Lakes. Males may attract females by releasing and dispersing urine that contains chemical signals. Females are attracted to water conditioned by reproductive males and to urine from reproductive males. One of the steroid derivatives that is found in this urine, 11-oxo-etiocholanolone-3-sulfate (11-oxo-ETIO-3-S) has strong olfactory potency to the round goby, but not to fish that share the round goby's habitat. However in lab tests, reproductive females were not attracted to solutions containing very dilute (0.01 nM) 11-oxo-ETIO-3-s that was isolated from reproductive male conditioned water. Possibly concentration dependent or synergistic factors affecting attraction responses may be at work during pheromone communication in the round goby. *Keywords: Round goby, Reproduction, Fish behavior, Olfactory, Pheromone.*

ZISOU, C.[1], LONG, T.L.[2], O'CONNOR, K.M.[3], HIRIART-BAER, V.P.[4], BOYD, D.[2], HALL, J.D.[3], YERUBANDI, R.[4], and ARHONDITSIS, G.B.[1], [1]University of Toronto, Ecological Modelling Laboratory, Toronto, ON, M1C 1A4; [2]Ontario Ministry of the Environment, Toronto, ON; [3]Hamilton Harbour Remedial Action Plan, Burlington, ON; [4]Environment Canada, Toronto, ON. **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, Eutrophication, Ecosystem modeling, Water quality criteria, Decision making, Risk assessment.*

ZOLFAGHARI, K. and DUGUAY, C.R., University of Waterloo, 200 University Avenue W, Waterloo, ON, N2L 3G1. **Chlorophyll-a Concentration Estimation in Lake Simcoe Using MERIS Satellite Data and a Linear Mixed Effect Model.**

High phytoplankton populations are harmful for water living species through the production of toxins. As an estimator of phytoplankton biomass, Chla is integral to monitoring water quality. It is a bio-optical characteristic of the lake. Satellite remote sensing provides a mean to measure Chla concentration for many lakes over large areas and with frequent temporal coverage. Lake Simcoe is located in southern Ontario and is the largest lake outside the Great Lakes system. Phosphorus loading has been increasing since the 1970s, significantly endangering water organisms. This research utilizes a Random Mixed Effect Model as the regression method to estimate Chla concentration from MERIS satellite data, acquired from 2002 to 2011 over the lake. A significant positive correlation was found between measured and predicted Chla ($R^2$=0.6). The model was used to study the temporal and spatial distributions of Chla in Lake Simcoe. The averaged Chla concentration in this period was the highest in fall (1.7 mg.m $^{-3}$) and lowest in spring (1.3 mg.m $^{-3}$). Spatially, the Chla concentration average value in the time period of study was lowest in the eastern and northern parts of the lake, and highest along the shoreline particularly in the southern part (0.6 mg.m $^{-3}$ - 22.9 mg.m $^{-3}$). *Keywords: Satellite technology, Lake Simcoe, Algae.*

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