ABSTRACTS

# IAGLR 2023 TORONTO

## Adapting to Climate Change

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# 66th Annual Conference on Great Lakes Research

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Conference logo by Jenifer Thomas

# CONTENTS

# ABSTRACTS

*An alphabetical listing of abstracts presented at the 66th Annual Conference on Great Lakes Research, organized by presenter. Presenters are underlined.*

## A

**Hazem Usama Abdelhady**[1] and Cary D. Troy[2], [1]Lyles School of Civil Engineering, Purdue University, West Lafayette, IN, USA, [2]Purdue University-West Lafayette, West Lafayette, IN, USA. **Great Lakes Wave Forecasting - A Machine Learning Approach.**

Wave climatology is one of the most important factors in planning, designing, and maintaining coastal structures. They are also essential for calculating all coastal processes. Thus, having long records of wave height is essential to calculate the design wave statistics with a reasonable confidence interval. Moreover, longer time series of wave climatology will help in studying the effect of climate change on wave climate. However, most of the available wave records are not long enough to obtain the wave height for long return periods. For example, the longest wave record available for Lake Michigan is through the Wave Information System (WIS), extended from 1979 to 2021, which provides us with only 42 years of wave data. However, wind stations at some airports around Lake Michigan have wind records dating back to the late 1940s. In this study, we collected wind speed and direction from all airports close to Lake Michigan that have wind records from 1950 or earlier. Then, machine learning was used with these data to create a model based on regional wind records. Ensemble of ConvLSTM 1D models trained on different parts of the training data set were found to have the best accuracy (RMSE) of 0.14 m on the testing data set. Although there were two wind stations close to the study site (~ 20 km), increasing the number of stations to include wind data from stations all around Lake Michigan, 18 stations, was found to significantly improve the accuracy and decrease the bias. The trained models were then used to hindcast the wave height from 1950 to 1979, which adds almost 30 years to the wave record.

**Dorine Achieng**, NSF-IRES Lake Victoria Research Consortium, Bowling Green, OH, USA. **Predicting the relationship between water hyacinth and cyanobacterial blooms in Lake Victoria.**

In recent years, harmful cyanobacteria blooms, especially Microcystic blooms, have been considered to be a common environmental issue. And have received worldwide attention as they can produce and release toxins that greatly harm aquatic ecosystems and cause potential hazard to human health to exist. To inactivate or remove cyanobacteria blooms, many methods and technologies have been explored. Mechanical algae removal has been proved to be one of the ways to use but it consumes a lot of energy and time. Other biological methods have been put in place which includes: using filter-feeding fish to graze algae and planting macrophytes to inhibit algal growth by excreting allelochemicals however, due to low transparency and low dissolved oxygen together with high concentrations of ammonia in the regions with dense cyanobacteria blooms, the survival rates of fish and transplanted macrophytes were so low that the effect of bloom control was not remarkable It is noticeable that whenever there are high concentrations of the blooms, there are high prevalence water hyacinth. This study hopes to establish the relationship between the existence of water hyacinth and cyanobacteria. If the two share nutrients of Nitrogen and Phosphorous for their growth and sustenance in aquatic environments.

Luc Goulet[1], **Josef D. Ackerman**[2] and Warren J.S. Currie[3], [1]University of Guelph, Guelph, ON, Canada, [2]Department of Integrative Biology, University of Guelph, Guelph, ON, Canada, [3]Fisheries and Oceans

Canada, Burlington, ON, Canada. **The effect of turbulence on the feeding of a freshwater grazer (*Daphnia magna*): The influence of algal size and shape.**

Zooplankton grazing is one of the most important interactions in aquatic ecosystems, yet the role of hydrodynamic forces is not fully understood. There are many factors that influence these interactions such as algal size/shape and encounters dictated by hydrodynamic. Hydrodynamic forcing typically lead to a unimodal relationship between grazer clearance rates (*CR*) because turbulence increases encounters but interferes with feeding at high levels. We examined the effect of algal size and shape on the *CR*-turbulence relationship by generating vorticity (local rotation) in a rotational cylinder to simulate increasing turbulence, and to analyze changes in swimming behaviour with increasing vorticity. The *CR* of *Daphnia magna* followed the unimodal trend as expected, and *CR* was higher on the small, spherical *Chlorella vulgaris* than on the larger, elongated and colonial *Scenedesmus quadricauda.* This was likely due to lower handling time and higher concentration of the smaller cells in the feeding radius around *D. magna.* The normal hop-sink swimming behaviour of the *Daphnia* was also affected with increasing vorticity, leading to lower hop frequency, higher displacement, and loss of vertical orientation. The pattern in these changes in feeding and swimming were predicted by vorticity rather than changes in Reynolds number (ratio of inertial:viscous forces), given that the conditions were always laminar in our experiments. Given the importance of vorticity in nature, it is relevant to examine grazer feeding interactions under relevant hydrodynamic conditions.

**Maya Adachi-Amitay**[1], Andrea Chreston[2], Hillary Morris[2] and Gail Fraser[1], [1]Faculty of Environmental and Urban Change, York University, Toronto, ON, Canada, [2]Toronto and Region Conservation Authority, Vaughan, ON, Canada. **Effects of *Phragmites* Invasion and Management on Wildlife Communities at Cell 1 Wetland in Tommy Thompson Park.**

The Cell 1 Wetland was constructed by TRCA on a decommissioned confined disposal facility at Tommy Thompson Park in 2005, and *Phragmites australis* (an invasive plant that quickly establishes in wetlands) was found in the emergent vegetation community in 2007. To restore native biodiversity and protect species-at-risk, TRCA employed various *Phragmites* control methods. Breeding bird surveys and observational wildlife sightings were examined with aquatic vegetation surveys over a 16-year period (2006-2021), classified in three phases: post-restoration; *Phragmites* dominated; and *Phragmites* controlled. Overall, the final phase of management resulted in greater bird nest success, with some species nesting at Cell 1 for the first time. While *Phragmites* may benefit generalist bird species, the *Phragmites* dominant community resulted in overall decreased bird species abundance, relative to a predominantly native plant community. Although species richness and abundance were lowest during the final phase, evenness was highest, indicating that *Phragmites* removal may be successful in increasing biodiversity over time. Cell 1 is a case study examining the implications of invasive plant establishment and management on wildlife in urban areas, serving as an example of effective ecological restoration to improve biodiversity.

**Aiesha Aggarwal**, The Couchiching Conservancy, Orillia, ON, Canada. **Community science and partnerships in water quality monitoring - Lake Simcoe and Nottawasaga River watersheds.**

The Couchiching Conservancy is a land trust that protects over 14,000 acres of natural land in the Eastern Georgian Bay watershed. Preserving the natural environment and promoting research and data sharing are two of the conservancy's central mandates. Community science monitoring has provided this non-profit organization with a capacity for large scale monitoring of waters in the Couchiching region. In 2015, fourteen volunteers were trained to monitor at 7 sites in the Carden Plain. Since the program's inception it has grown and evolved. Thanks to the dedication over 40 volunteers, partnerships with local organizations and funders, community science monitoring has had many successes, including gathering baseline water-quality data for 40 sites, identifying brook trout habitat, and raising public awareness about local water quality issues. This presentation will discuss the benefits of community science and follow the development of a successful program, including experiences with training, data collection, and data

management. Going into its 7th year, the program continues to evolve, with new partnerships with Water Rangers and Data Stream in the works.

**Laya Ahmadi** and Christopher Wellen, Toronto Metropolitan University, Toronto, ON, Canada.
**Integrating detailed land management information into statistical watershed phosphorus loading models.**

Eutrophication is a continuing water quality hindrance in the Laurentian Great Lakes, and is strongly influenced by excess phosphorus inputs. There is significant interest in reducing phosphorus losses to downstream ecosystems from multiple sources, including agricultural nonpoint sources. Experimental edge of the field research has highlighted the importance of many types of beneficial management practices (BMPs) in reducing nutrient export to water bodies downstream. Mechanistic modelling studies have estimated watershed scale reductions of phosphorus loading as a result of many of these BMPs. However, empirical evidence at the watershed scale for decreased loading of nutrients due to the adoption of BMPs remains elusive. This is partly due to the paucity of approaches to empirically link land management with water quality. This research applies general additive models (GAMs) to integrate information from a well monitored stream on the Canadian side of the Laurentian Great Lakes with a land management survey administered there. We rigorously assess whether land management information can be incorporated into a simple statistical model of stream total and dissolved phosphorus loading.

**Paska Ajok**, Kampala, Uganda. **The impact of the 2020-2021 rising water levels in Uganda's major lakes and the floods in the lake shores.**

Lake Victoria is the largest lake in Africa and one of the largest lakes in the world. Between 1961 and 1964, the level of the lake rose unexpectedly by almost 2.5 m. Subsequent analyses have linked this rise to unusually heavy rainfall in East Africa in late 1961 and early 1962 and corresponding increases in the direct rainfall on the lake surface and the tributary inflows to the lake. However, levels have remained high since that time leading to doubts about the likely future behavior of the lake. This doubt in the behavior of the Lake was confirmed after 56 years, the lake levels decreased to a lowest level recorded in 2006 since then the level has been constant. From 2018 the lake levels started rising possibly due to heavy rainfall in East Africa leading to a new high record of 1136.5masl in May 2021 surpassing that of 1964, Increase in L Victoria level for Uganda means an increase in the outflow through the Nile which subsequently increases the levels of L. Kyoga and Albert. Using Remote sensing and spatial analysis tool in GIS the extent of 2020 and 2021 flooding was mapped for Kyoga and Albert and field validation exercises carried out to ascertain the impact of flooding to inform decision. Ever since the water levels of these major lakes started rising sharply in April 2020, Lake Victoria water level rose by **0.50** meters compared to the 1964 record and that of Lake Kyoga rose by **1.91** meters while that of Lake Albert rose by **2.68** meters, this caused a lot of havocs on the structures along the lake shores submerging hotels, houses, beaches, landing sites, islands, Dams and destroying livelihood.

**Razegheh (Raz) Akhbarizadeh**[1], Yan Jin Xu[1], Katie Wang[1], Freya Boerner[1], Miriam L Diamond[1,2] and Paul Helm[2,3], [1]Department of Earth Sciences, University of Toronto, Toronto, ON, Canada, [2]School of the Environment, University of Toronto, Toronto, ON, Canada, [3]Environmental Monitoring and Reporting Branch, Ontario Ministry of the Environment, Conservation and Parks, Toronto, ON, Canada. **Validating improved sampling and extraction procedures for microplastics in complex water samples.**

Urban streams and rivers are important pathways for microplastics (MPs) and other anthropogenic particles (e.g., plastic pellets, foams, tire wear) entering the Great Lakes. Well-tested, robust, and replicable sampling and digestion methods are needed to obtain representative and comparable data for use in loadings analysis, benchmarking, source tracking, etc. We conducted a systematic investigation of typical stream sampling procedures to assess sampling efficiency, and digestion extractions to minimize MP degradation

while maximizing removal of abundant, complex organic matter (OM) using spiked MPs. We found that bulk water sampling using pumps and bucket grabs provided accurate estimates of MP (63-1000 μm), while net sampling (250 μm screen mesh) had lower recoveries for various shapes and sizes of MPs (20-50% for fibers; 70% for foams, both >300 μm). Results showed that sample digestions using a combination of the oxidative-alkaline solutions were more effective for eliminating OM (88-95% mass reduction) than Fenton's digestion alone (77%). The presence of OM mitigated the impacts of digestion solutions on susceptible particles. Thus, quality control spikes should include OM to mimic sample matrices. These protocols balanced efficiency (time and effort) and effectiveness (maximize removal of OM) for complex urban water.

**Oluwatosin Joseph Aladekoyi**, Patricia Hania, Martina Hausner, Rania Hamza and Kimberley Gilbride, Toronto Metropolitan University, Toronto, ON, Canada. **Evaluating the impacts and the management of pharmaceuticals released into the Canadian aquatic environment.**

Despite the different impacts that research has shown that pharmaceuticals (PhACs) can have on aquatic health, literature has yet to comprehensively examine their synergistic and long-term effects. Also, across all levels of government in Canada, no policies nor legislation exists that is focused on removing PhACs or limiting the rate at which they enter water sources via wastewater effluents from WWTPs. For instance, the Wastewater Systems Effluent Regulations fails to include a parameter for PhACs. Despite the existence of the Chemicals Management Plan (CMP), which set out guidelines for the assessment and management of PhACs under the *Canadian Environmental Protection Act, 1999* (CEPA), no PhACs have been regulated despite literature evidence of toxicity. A further complicating factor is that the CMP does not consider their synergistic effects on aquatic health. The result is a legislative and aquatic health gap regarding the release of PhACs from point sources such as WWTP. This research raises the question: How can the governments effectively protect the aquatic environment from PhAC-contaminated WWTP effluents? This article adopts an evaluative approach to explore the current management and legislative options that exist in Canada to protect aquatic health from PhACs. It also compares Canada to other international jurisdictions to see if there are lessons that could be learned from their responses. The article concludes by recommending sustainable options that could be adopted in Canada to better protect the aquatic environment from CECs such as PhACs.

**Lewis J Alcott**, Fereidoun Rezanezhad and Philippe Van Cappellen, Ecohydrology Research Group, University of Waterloo, Waterloo, ON, Canada. **Direct Wastewater Treatment Plant Inputs of Microplastics to the Laurentian Great Lakes.**

Effluent of wastewater treatment plants (WWTPs) are an important point source of pollutants to aquatic environments. Whilst not built for this purpose, WWTPs have high microplastics retention capacities (often >70%). Thus, they can serve as important control points to reduce microplastics pollution to receiving water bodies. In this study, we used a combination of the *Our World in Data* mismanaged plastic waste database plus socioeconomic data from the *International Joint Commission* and *Great Lakes Commission,* to estimate the annual inputs of microplastics associated with direct wastewater discharges into each of the five Laurentian Great Lakes. The empirical calculations take into account the population sizes bordering the lakes' coastlines and downstream reaches of tributary rivers, as well as the relative proportions of primary, secondary, and tertiary treatment of the discharging WWTPs. These inputs are then tracked within a simple microplastics balance model. Next, the model is used to assess the impacts of converting and improving wastewater treatment processes along the Great Lakes continuum. Future work will further consider other possible scenarios, e.g., diminishing per capita microplastic emissions and projected population growth in the Great Lakes region.

**Achieng Alfred Otieno**[1], Matthew McCandless[2], Lars G. Rudstam[3], Ted J Lawrence[4,5], Paris D Collingsworth[6], George B. Arhonditsis[7], Jay A Austin[8], Stephanie J Guildford[9], Robert E Hecky[10], Ken

Irvine[11], Julius Otieno Manyala[12], Orlane Anneville[13], Catherine M Febria[14], Zephenia Migeni Ajode[15], Kevin Odhiambo Obiero[16], Paul Kithome Mumina[17] and Neil Rooney[18], [1]University of Eldoret, Eldoret, Kenya, [2]IISD Experimental Lakes Area Inc., Winnipeg, MB, Canada, [3]Cornell Biological Field Station, Bridgeport, NY, USA, [4]African Center for Aquatic Research and Education, Ann Arbor, MI, USA, [5]International Institute for Sustainable Development, Winnipeg, MB, Canada, [6]Purdue University, West Lafayette, IN, USA, [7]Ecological Modeling Laboratory, Department of Physical and Environmental Sciences, University of Toronto, Toronto, ON, Canada, [8]University of Minnesota, Duluth, Duluth, MN, USA, [9]Journal of Great Lakes Research, Kitchener, ON, Canada, [10]formerly University of Minnesota-Duluth, Kitchener, Canada, [11]IHE-Delft, Delft, Netherlands, [12]Jaramogi Oginga Odinga University of Science and Technology, Kisumu, Kenya, [13]INRA, Thonon-les-Bains, France, [14]Healthy Headwaters Lab, University of Windsor, Windsor, ON, Canada, [15]African Center for Aquatic Research and Education, Kisumu, Kenya, [16]Kenya Marine and Fisheries Research institute, Pap-Onditi, Nyanza, Kenya, [17]Kenya Fisheries Servise, Nairobi, Kenya, [18]University of Guelph, Guelph, ON, Canada. **Large lakes of the World: Lessons from the Laurentian and African Great Lakes.**

The compounded impact of human footprints on the large lakes of the world are disproportionately studied in the global north compared to the global south. In the north, government agencies and research associations have established a tradition to hold conferences that communicate new developments or advances in research and inform stakeholders on sustainable resource use, conservation and management of these lake ecosystems. These activities are also increasing in the global south. In this review, the IAGLR International Committee together with experts from the Laurentian and African Great Lakes evaluate the structures and model of implementation that facilitate the success of this tradition, such as, institutional involvement, database and accessibility, financial feasibility and sustainability, government support (especially for transboundary resource-relationships between or among countries), and finally, the strength of research collaborations. We draw lessons on lake ecosystem management by comparing the two regions and provide recommendations on planning for the African Great Lakes Conference scheduled for 2026, in addition to future collaborations and research funding in the global south.

**Quinn Allamby**[1], Karen Kidd[1] and Ryan Prosser[2], [1]McMaster University, Hamilton, ON, Canada, [2]University of Guelph, Guelph, ON, Canada. **Accumulation and toxicity of environmentally relevant microplastics exposures in freshwater macroinvertebrates.**

Microplastics (MPs) pollution has quickly become one of the most pressing environmental issues to date. However, freshwater macroinvertebrates are vastly underrepresented within the current MPs literature, despite their extensive use in aquatic biomonitoring. Therefore, this study aimed to address this gap through ecologically realistic exposures using freshwater macroinvertebrates. For the experiments, three macroinvertebrate species, *Tubifex tubifex*, *Planorbella pilsbryi*, and larval *Hexagenia* spp., and two MPs types, polystyrene microbeads (6µm) and polyester microfibers (100µm), were used. For each species, four tests were conducted: pristine microbead and microfiber exposures, and "aged" microbead and microfiber exposures, across a range of concentrations. MPs "aging" was incorporated into this experiment to replicate the microbial attachment and biofilm formation on MPs within the environment. To assess toxicity, reproduction and survival were measured across all tests following MPs exposure. To date, no significant effects to reproduction or mortality have been observed for any of the three species, or for either type of MPs, aged or pristine. However, preliminary results suggest that organisms are ingesting MPs, with large amounts of MPs present in feces following exposure. Bioaccumulation analysis is currently underway. This study will provide new insights regarding the potential impacts of MPs to freshwater macroinvertebrates to determine the risks and implications of MPs contamination in freshwater ecosystems.

**Erin B. Allen**[1], Megan L. Norris[2], Amanda K. Suchy[3] and Donald G. Uzarski[3], [1]St. John's College, Annapolis, MD, USA, [2]Coe College, Cedar Rapids, IA, USA, [3]Central Michigan University, Mount Pleasant,

MI, USA. **Nutrient-dependent effect of microplastic and anthropogenic fiber on phytoplankton productivity.**

Anthropogenic micropollutants like microplastics and other textile fibers are a growing concern in aquatic systems and have been shown to have adverse effects throughout the food web from primary producers to vertebrates. Given microfibers in freshwater lakes with increased anthropogenic activity may come in contact with other pollutants, like nitrogen and phosphorus, it is unclear how different microfibers might interact with other water quality parameters to affect phytoplankton growth; this study aimed to determine how introduced anthropogenic fibers in the presence of various nutrients may impact phytoplankton productivity, using chlorophyll *a* analysis as a proxy for phytoplankton biomass and trichromatic chlorophyll analysis to observe growth differences between phytoplankton taxa. An eight-day incubation of gathered lake water with different synthetic and natural microfiber and nutrient additions was conducted, followed by chlorophyll extraction and spectroscopic analysis. The results showed inhibited overall phytoplankton growth in treatments with cotton fibers under phosphorus additions, and lower concentrations of chlorophyll *c* in microfiber treatments under no nutrient additions. These findings suggest interactions between different microfibers and nutrients that effect overall and taxa-specific phytoplankton growth, and indicate the need for further study to determine how other water quality parameters may influence the effect of microfibers on aquatic communities.

**Zane Almquist**[1], Michael J. Sayers[1], Peter C Esselman[2], Ben Hart[1], Robert A. Shuchman[1] and Karl Bosse[1], [1]Michigan Tech Research Institute, Ann Arbor, MI, USA, [2]U.S. Geological Survey, Great Lakes Science Center, Ann Arbor, MI, USA. **Evaluation of satellite spatial resolution impacts on detection and mapping of submerged aquatic vegetation.**

The mapping of submerged aquatic vegetation (SAV) has gained widespread interest in the Great Lakes region as ecological changes have increased the range and density of SAV. Cladophora, a filamentous nuisance algae, is of particular concern, as it has harmful effects when it sloughs off the bottom in significant amounts. Remote sensing techniques can be applied in nearshore areas to estimate SAV extent and density, providing valuable information to stakeholders. Understanding the differences in SAV detection and mapping with sensors of varying spatial resolution will allow for more targeted sensor selection in the future monitoring of SAV. Michigan Tech Research Institute (MTRI) mapped cladophora and other SAV in the Great Lakes in 2012 and 2018. In 2020 and 2021, USGS deployed an autonomous underwater vehicle (AUV) paired with an MTRI-built radiometer to collect photos and radiometric data at 5 sampling locations near within the Sleeping Bear Dunes National Lakeshore in Lake Michigan. Using USGS products derived from the images captured by the AUV, MTRI estimated percent SAV coverage at a spatial resolution of > 0.5 m. The *in situ* derived SAV estimates were then resampled to the spatial resolutions of multiple space-borne sensors, including WorldView, Landsat, and Sentinel-3, and resulting differences in estimated SAV extent were computed.

**Karen Alofs**[1] and Cory Brant[2], [1]University of Michigan, School for Environment and Sustainability, Ann Arbor, MI, USA, [2]USGS Great Lakes Science Center, Ann Arbor, MI, USA. **A methodology for comparing historical and contemporary coregonine distributions to inform restoration.**

One of four tasks within the Coregonine Restoration Framework for the Laurentian Great Lakes is to conduct a 'gap analysis' which will compare the historical and contemporary distributions of coregonine species. We describe a method for accomplishing this task that was developed by a cross-basin team and recently reviewed and adopted by the Council of Lake Committees. The method focuses on spawning habitats and was developed at a basin-wide scope; however, it can be applied at smaller ecological scales to address regional variation and management priorities and where high-quality data are available. The method focuses on three subtasks: 1) collecting and databasing information on spawning locations and habitat variation, 2) developing and assessing species distribution models that predict habitat suitability and address sampling biases, and 3) comparing historical and contemporary population and habitat distributions. This

process will be undertaken in collaboration with managers and partners and will aid in the evaluation of spatial units for potential restoration and conservation opportunities.

**Peter J Alsip**[1], Alex Kain[1], Mark D. Rowe[2] and Casey M Godwin[1], [1]Cooperative Institute for Great Lakes Research, University of Michigan, Ann Arbor, MI, USA, [2]NOAA GLERL, Ann Arbor, MI, USA.
**Developing light attenuation models for use in Great Lakes biophysical models.**

Developing aquatic ecosystem models capable of resolving phytoplankton ecology and higher orders of ecosystem processes require adequate representation of the light environment. Variability in photosynthetically active radiation (PAR) within the Laurentian Great Lakes (LGL) is largely driven by the abundance of suspended sediments (SS) and dissolved and particulate organic material in the water column. The variable optical properties within a single lake and across different lakes complicates the ability to develop robust models of PAR attenuation. We consolidated a multi-lake dataset of PAR profiles and co-located water quality data to develop a suite of models for predicting PAR attenuation throughout the LGL as a function of water quality constituents. We evaluated model performance across a wide range of water quality conditions and installed the most skilled PAR attenuation model into a lower food web model and linked it to a sediment resuspension model and the Finite Volume Community Ocean Model for Lake Erie. We will present examples demonstrating the model's skill in simulating recurrent and episodic spatial patterns in PAR attenuation, SS, and organic material by comparing it to satellite-derived values and in-situ observations. These SS and PAR attenuation models may be used in phytoplankton, lower food web, and biogeochemistry models to support adaptive management of nutrient inputs and fisheries.

**Joshua D. Anderson**[1], Y. Joseph Zhang[2] and Chin Wu[1], [1]University of Wisconsin-Madison, Madison, WI, USA, [2]Virginia Institute of Marine Science, Gloucester Point, VA, USA. **Coastal upwelling mechanisms and characteristics along the Keweenaw Peninsula, Lake Superior.**

Coastal upwelling is a dynamic process that affects many important aspects of the Great Lakes, including municipal drinking water, dissolved oxygen, primary productivity, pollutant dispersal, and human safety. Due to the complex spatial and temporal variability of physical properties that influence upwelling, the mechanisms, occurrence, and resulting characteristics of events are not known along many coasts of the Great Lakes. In this talk, coastal upwelling along the Keweenaw Peninsula of Lake Superior is examined using observations and application of the hydrodynamic model SCHISM over the stratified seasons of 2017-2021. SCHISM is shown to produce comparable upwelling event characteristics to available thermistor chain data and similar spatial structure as observed by AVHRR satellite measurements. Applying SCHISM results, mechanisms of upwelling and the resulting characteristics are examined to reveal the spatial variability along the Keweenaw Peninsula. Full upwelling, where the thermocline is raised to the surface, is found to occur multiple times per stratified season with high variability in the location of the upwelling front. However, a stretch of shoreline approximately from the Keweenaw Waterway to Eagle Harbor is found to most frequently experience full upwelling due to local winds orienting alongshore and steep bathymetry. Finally, the interaction of inertial motions on a full upwelling front will be demonstrated and discussed.

**Eric J Anderson**[1] and Chin Wu[2], [1]Colorado School of Mines, Golden, CO, USA, [2]University of Wisconsin-Madison, Madison, WI, USA. **Detection of Meteotsunamis in Lake Michigan.**

Information on hazards facing coastal communities in the Great Lakes comes from a limited set of in-situ observations, forecast products, and in some cases remote-sensing capabilities. The majority of these in-situ observations along the coast are limited to surface wind-wave buoys and on-shore or inland water level gauges. While these networks of observing platforms are useful for many Great Lakes hazards, they are only sensing a subset of the frequency spectrum of water level fluctuations that exist, more specifically those of wind-waves, seiche, storm surge, and seasonal/annual changes. Recent literature has demonstrated these

observations fail to adequately characterize high-frequency fluctuations like those associated with meteotsunamis. Even when meteotsunami events are detected by coastal gauges, they may still underestimated the hazards along the open coast. In this effort, we analyze datasets from open-water, nearshore instruments that are designed to measure high-frequency water level fluctuations. Results show that in-lake observations can differ significantly from those recorded at coastal or inland water level gauges.

**Evan A. Angus**[1], James W. Roy[2,3], Thomas A. Edge[4], Christopher J. Jobity[3] and Clare E. Robinson[3], [1]Department of Civil and Environmental Engineering, University of Western Ontario, London, ON, Canada, [2]Water Science and Technology Directorate, Environment and Climate Change Canada, Burlington, ON, Canada, [3]Department of Civil and Environmental Engineering, Western University, London, ON, Canada, [4]Department of Biology, McMaster University, Hamilton, ON, Canada. **Factors influencing fraction of septic system wastewater effluent delivered to tributaries.**

In the Lake Simcoe watershed, septic systems are used in approximately 30,000 homes that are not serviced by centralized wastewater treatment. The contribution of nutrients and contaminants of concern (e.g., fecal contaminants, pharmaceuticals) from septic systems to tributaries in the Lake Simcoe watershed is unclear, particularly as there are other sources for these nutrients and contaminants. Simple models estimate the contributions by applying a constant fraction to the estimated effluent produced by all the septics systems in the watershed. To refine watershed estimates of the contribution of septic systems to nutrient tributary loads there is a need to evaluate potential controlling factors influencing the fraction of effluent reaching tributaries, including physical (e.g., land use, agricultural drainage, geology) and demographic (e.g., home age, median income) characteristics of a subwatershed. To meet this knowledge gap, broad-scale water quality sampling was conducted at 53 tributaries across Ontario, with 39 in the Lake Simcoe watershed. Stream grab samples collected on 4 occasions across seasons were analyzed for wastewater tracers (artificial sweeteners, HF183 marker) to determine the amount of septic effluent reaching each tributary. Initial statistical analyses show the fraction of septic effluent reaching a tributary is higher in subwatersheds with older homes, more built-up area, and more tile drainage. The study findings are needed to improve nutrient load estimates and to inform septic system best management practices.

**Juan Arce-Rodriguez**[1], Christina Zeuner[2], Jana Levison[3] and Marie Larocque[4], [1]Water Resources Engineering, University of Guelph, Guelph, ON, Canada, [2]Environmental Engineering, University of Guelph, Guelph, ON, Canada, [3]University of Guelph, Guelph, ON, Canada, [4]Université du Québec à Montréal, Montréal, QC, Canada. **Examining Agricultural Nitrogen Transport in a Southern Ontario Sand Plain System.**

Understanding the transport of agricultural nutrients throughout watershed systems, including surface and groundwater, is of great importance for decision-makers, stakeholders and farmers, for adequate quantity and quality of water resources. Agriculture can impact the water quality in rural areas, compromising food safety and potable water availability for present and future generations. The objective is to examine the mechanisms of nitrate transport from agricultural soils to groundwater systems, in a rural agriculture-dominated watershed using the DNDC (denitrification/decomposition) model informed by field data. The research area is in the Lower Whitemans Creek sub-catchment located in the Lake Erie Basin (Ontario), which consists of a sandy aquifer with a shallow water table, and there is extensive agricultural land use. Soil physicochemical characteristics, yearly land use and data about agricultural practices were used as inputs to the 1D model. Monthly (over 1.5 years) groundwater nitrate concentrations are used to calibrate and validate the model. This research is useful for understanding how farming practices influence water quality in agriculture-dominated watersheds, and eventually help with land zoning and decision making.

**Dana Arends**[1] and Jason Olsthoorn[2], [1]Queen's University, Kingston, Canada, [2]Civil Engineering, Queens University, Kingston, ON, Canada. **Modelling the influence of bathymetry on local melt rates of an idealized ice-covered lake.**

Ice-covered lakes play an essential role in regulating regional weather and climate during winter months while also providing important transportation and recreational benefits to humans' lives. Climate change is increasing the temporal variability of the ice-covered period for these lakes. However, it is still not well understood how the spatial variability in lake ice cover thickness is influenced by large-scale under-ice flow structures. To expand our knowledge on this matter, a simplified 3D lake ice growth model has been set up using AEM3D for a series of bathymetry cases with differing side slopes and maximum depths. Each case is being run with a set of the most important parameters contributing to water circulation turned both on and off to assess how the resulting flow structure influences heterogenous melting. The results will determine if a potential link between melt rate and local depth exists. The outcome of this research could have implications in answering the question of whether the morphometry of a lake can be inferred based on the ice melt pattern observed at the surface.

**George B. Arhonditsis**, Ecological Modeling Laboratory, Department of Physical and Environmental Sciences, University of Toronto, Toronto, ON, Canada. **Integrating Regional Assessment with Watershed Planning and Field-level Implementation.**

My primary objective is to highlight the establishment of multimodel ensembles as an appealing strategy that can support adaptive watershed management in the Great Lakes. I identify three strategies that have different implications for the granularity of the analysis, empirical knowledge and data input demands, and required time frame to operationalize the models. The first option resembles the watershed modelling work in the Maumee River watershed, where the characterization of the watershed attributes and functioning that modulate nutrient loading will be based on multiple independent SWAT applications with different process characterizations. Before implementing SWAT, I propose the use of SPARROW —a data-driven model— to delineate hot-spots, examine landscape predictors for nutrient mobilization and retention, and use these results to inform the SWAT models. The third option introduces farm and edge-of-field monitoring and (APEX) modelling to refine the spatial resolution and design in-field conservation practices that mitigate nonpoint source pollution from agriculture. My study pinpoints data monitoring needs to elucidate critical unknowns of the watershed functioning, such as the role of legacy phosphorus (P), the causes of the increasing long-term trends in dissolved reactive P loading, the challenges in reproducing spring-freshet or event-flow conditions, and the dynamic characterization of water/nutrient cycles under the non-stationarity of a changing climate.

**Paige Arieno**[1], **Jayson Kucharek**[1], Evan Batte[1], Nicole Fuller[1], Steven Day[1], Nathan C Eddingsaas[2], Matthew Hoffman[1], Andre Hudson[1] and Christy Tyler[1], [1]Rochester Institute of Technology, Rochester, NY, USA, [2]School of Chemistry and Materials Science, Rochester Institute of Technology, Rochester, NY, USA. **Input of anthropogenic debris across a rural-urban gradient in the Lake Ontario watershed.**

Anthropogenic debris, including plastic, is problematic in the Great Lakes, but little is known about sources and movement of debris in the watershed. We evaluated the input and transport of debris along a rural to urban landscape gradient in the watershed of the Rochester Embayment of Lake Ontario. Input was assessed using three methods: LittaTraps installed in stormwater drains in the city of Rochester and the suburban Town of Brighton; modified Manta trawls deployed in rural and suburban streams; and Seabins installed at the mouth of three major tributaries. Collected debris was weighed, sorted and characterized. Debris was comprised of plastic, glass, metal, paper, organic matter, and composite items, with high spatial and temporal variability in composition and abundance. Some variation resulted from surrounding landscape characteristics: more plastic and metal debris were found in urban commercial areas and more organic debris in suburban areas. Further analysis will include metagenomic analysis of plastic-associated

biofilms and degree of in situ degradation. With these data, we will use census block group variables in GIS to statistically model the sources and sinks of debris entering Lake Ontario from the watershed.

**Isaac Armstrong**[1], Katherine E Moir[1], Jeffrey J Ridal[2] and Brian F Cumming[1], [1]Queen's University, Kingston, ON, Canada, [2]St. Lawrence River Institute, Cornwall, ON, Canada. **Subfossil chironomid assemblages show ecological recovery in the Cornwall, ON waterfront.**

Management of the historically contaminated waterfront at Cornwall, ON, relies on natural processes to isolate sedimentary contaminants. Determining the efficacy of this strategy in reducing risk to benthic invertebrates is complex as pollution impacts within the waterfront are spatially heterogeneous and modern-day climate warming may interact with contamination impacts and/or confound recovery signals. Long-term biological data from sites with unique stressor combinations are required to disentangle effects and assess whether benthic recovery has occurred. We compare long-term records of subfossil chironomid (Diptera: Chironomidae) assemblages among sediment cores from two contaminated Cornwall sites as well as a downstream reference site. Cornwall sediment cores show a functional absence of chironomids that co-occurs with high contaminant concentrations during the period of historic industrial activity. As contaminant concentrations decrease over time, chironomid abundance and the relative abundance of pollution-sensitive taxa increase. Recent intervals in all three sediment cores display increased relative abundance of warm-water, macrophyte-associated taxa. We conclude that recovery has occurred in both waterfront sites and that climate warming is affecting chironomid assemblages at a regional scale.

**Carlos Alberto Arnillas**, Lamees Shah, Alex Neumann and George B. Arhonditsis, Ecological Modeling Laboratory, Department of Physical and Environmental Sciences, University of Toronto, Toronto, ON, Canada. **Key steps toward a holistic crop modelling framework.**

Farmlands are the most prevalent impact of humans on nature, and their challenges are represented in the debates of organic farming and land-sharing vs. land-sparing. Field and farm models have been used to optimize crop management, but with limitations. For example, some first principles strongly support linking photosynthesis, productivity, and leaf-level N and P content. But these theoretical formulations often use simplifications that neglect spatial and temporal heterogeneity, as well as biodiversity. Hence, most models apply to single crop systems with competitive intraspecific interactions, while facilitation, intercropping, or invasions by weeds or pests are seldom dynamically modelled, although they are crucial. For instance, models often represent plowing by focusing on soil mixing and erosion; however, by not representing species interactions, the models neglect a crucial reason to plow: prevent weeds. Further, models unable to represent their surroundings cannot assess strategies recommended to improve the farm's, environment's and people's health. Here we discuss a simple question: what is the minimum set of variables needed to represent the potential benefits of organic farming? Starting from a holistic perspective, we review conceptual frameworks (like photosynthesis models, invasion theory, and metabolic scaling theory) that could represent them, their uncertainty issues, and how to integrate them.

**Anthony J Arnold**[1,2], Samuel D Pecoraro[2], Peter C Esselman[3] and Joe Geisz[1,2], [1]Michigan Technological University, Houghton, MI, USA, [2]United States Geological Survey, Ann Arbor, MI, USA, [3]U.S. Geological Survey, Great Lakes Science Center, Ann Arbor, MI, USA. **High Resolution Multibeam Mapping and AUV Ground-Truthed Habitat Assessment of Fish Spawning Reefs in Lake Michigan.**

Lithophilic fish species spawn on and hatch from shallow, rocky reefs, including lake trout, lake whitefish, and cisco, which are critical to Great Lakes fisheries. These reefs have become degraded from the effects of logging legacies coupled with the more recent threats of sedimentation, invasive mussels, and Cladophora. Active research is ongoing to identify reef restoration opportunities. Needs assessments from partner organizations resulted in the surveying of eighteen known fish spawning reefs in 2021 and 2022 using a multibeam echosounder. An Iver-3 AUV equipped with a 12-megapixel color camera provided

concurrent georeferenced ground truth imagery data. Multibeam data were processed to derive very high resolution (0.5m gsd) bathymetry and backscatter rasters, in order to compare reef extents and develop derived geomorphic and substrate classification models. These are the highest resolution map products of these sites to date which can be used to determine reef restoration goals, extent of sediment infilling, as well as viability as fish stocking habitat.

**Nathaniel Arringdale**[1], Karl Bosse[1], Michael J. Sayers[1], Steve Ruberg[2], Andrea Vander Woude[2] and Russ Miller[3], [1]Michigan Tech Research Institute, Ann Arbor, MI, USA, [2]NOAA GLERL, Ann Arbor, MI, USA, [3]Cooperative Institute for Great Lakes Research (CIGLR), Ann Arbor, MI, USA. **Evaluating Remote Sensing Retrievals of Particulate Backscatter.**

The particulate backscattering coefficient ($bb_p$) is a key inherent optical property of water which provides useful information about biological and geologic processes within large lake systems, such as the Laurentian Great Lakes. Depending on water type, a strong relationship has been observed between $bb_p$ and concentrations of suspended sediments and chlorophyll-a. Using an extensive in situ $bb_p$ dataset with measurements from across the Great Lakes (n=789), we analyzed the performance of different algorithms for estimating $bb_p$ from optical remote sensing data. These algorithms included MTRI's Color Producing Agents Algorithm (CPA-A) which was calibrated specifically for the Great Lakes, and the Generalized Inherent Optical Properties (GIOP) and Quasi-Analytical Algorithm (QAA) which were developed for global application. We found the CPA-A approach had a comparable $bb_p$ retrieval accuracy relative to the more established retrieval methods. However, the CPA-A had a greater retrieval rate than the GIOP or QAA due to differences in the algorithms' flagging methods. When comparing retrievals where all methods obtained a valid value, the CPA-A outperformed all other methods. Another trend was a negative bias across all methods. Overall, developing a $bb_p$ retrieval method specifically for the Great Lakes will help with monitoring water quality using remote sensing. This creates the possibility of identifying and mapping water quality across the Great Lakes.

**Anthony Arsenault**, Trent University, Peterborough, ON, Canada. **Great Lakes Winter Grab: Dissolved organic matter in and under the ice across a nutrient gradient.**

Winter Grab is a cross-border coordinated sampling campaign between Canada and the USA whose aim is to increase our understanding of winter limnology in the Great Lakes. To help fill a knowledge gap in dissolved organic matter (DOM) dynamics in the winter, we sampled 49 sites across all 5 Great Lakes and assessed DOM quantity (DOC) and composition in the ice and water, as well as nutrients and chlorophyll *a* in the water. Consistent with past studies, we found that DOC was on average much lower in the ice (0.62 mg/L) than in the water (4 mg/L). Furthermore, DOM in the ice was composed mostly of protein-like and microbial-like components, whereas DOM in the water was predominantly terrestrial or humic-like. This result was most pronounced in the nutrient-rich Lake Erie samples. Our results demonstrate the importance of ice for supplying bio-labile carbon to the Great Lakes.

Brian K. Ginn[1], Eavan M. O'Connor[1], Joelle Young[2], **Lance Aspden**[1] and David Lembcke[1], [1]Lake Simcoe Region Conservation Authority, Newmarket, ON, Canada, [2]Ontario Ministry of the Environment, Conservation and Parks, Toronto, ON, Canada. **Phosphorus loads to Lake Simcoe and in-lake conditions: investigating the impacts of nutrient decoupling.**

Phosphorus inputs to Lake Simcoe are a key indicator of the Lake Simcoe Protection Plan (LSPP) and the environmental status of the lake, and have historically been related to in-lake nutrient concentrations, algal populations, and deepwater dissolved oxygen concentrations, a critical target of the LSPP. However, since around 2009, these environmental conditions being recorded in Lake Simcoe seem to have become decoupled, i.e., seemingly unrelated, to changes in phosphorus inputs. This presentation will provide updates on phosphorus loads for the years 2018-2020 and our work to understand the apparent

decoupling of these loads from in-lake nutrient / dissolved oxygen conditions over the past decade, as well as consider the need to rebuild our predictive environmental models for in-lake nutrient cycling dynamics. With many similarities to the Great Lakes, the environmental trends recorded on Lake Simcoe have direct comparisons to the larger lakes, as well as potential impacts to their environmental management strategies.

**Faith Atukwatse**, Pearl Aquatics Limited, Kampala, Uganda; Makerere University, Kampala, Uganda.
**Occurrence of microplastics in *Oreochromis niloticus* from fish breeding areas of northern Lake Victoria.**

Microplastics (Mps) are plastic particles smaller than 5 mm. Mps are either primary if discharged directly into the environment as micro- or nanosized particles or as secondary if they result from disintegration of larger plastic materials during usage or after disposal as wastes. Urban centers on Lake Victoria produce Mp wastes that are carried by wind and rainwater into the lake. When plastics and microplastics are discharged in freshwater systems, they settle either on the shores, shallow surface waters, or sediments in at least 200m from the water body's shoreline. During spawning seasons, *O.niloticus* fish move to sheltered shoreline areas that give the broodstock and juveniles protection against predators, strong currents, extreme temperatures, and light. Also, to get plenty of food including insects and eggs. Mps have recently been found along the shores, surface waters, and sediments in the northern region of Lake Victoria and this exposes them to fish. Ingestion of Mps by fish can led to intestinal blockage, physical damage, change in behavior, transfer of adsorbed pollutants like heavy metals, and even mortality to fish. Ingestion of microplastics by fish fry, juvenile, and broodstock in fish breeding areas jeopardizes their growth & development. The study aims at ascertaining the presence of Mps in the gastrointestinal tracts and gills of *O.niloticus* from breeding areas in northern region of Lake Victoria. Information from the study will guide relevant environmental and health authorities on proper Mp disposal for a sustainable Nile tilapia fishery.

**Mary Austerman**[1] and Jayme Breschard[2], [1]NY Sea Grant, Newark, NY, USA, [2]Barton & Loguidice, Rochester, NY, USA. **Using Scenario Planning to Build Resilient Communities.**

The uncertainties and complexities of climate change ad associated impacts can leave a community feeling overwhelmed and hinder adaptation planning. The first step in being proactive and integrating climate projections into land use planning is to consider plausible futures. Many community leaders lack a simple and inexpensive process to accomplish this. This session introduces the concept f scenario planning as a starting place for capacity builders to utilize with communities that are interested in thinking through the impacts of climate drivers on their watersheds and floodplains, and identifies examples of exiting tools and resources to help facilitate the process.

**Jay A Austin**, University of Minnesota, Duluth, Duluth, MN, USA. **The fall transition in deep, dimictic Lake Superior.**

Dimictic lakes go through two transitions each year: a spring transition, where the lake undergoes a period of convection following the negatively stratified winter, leading to positive summer stratification, and a fall transition from positive to negative stratification. These two processes are not simply mirror images of each other; they consist of dynamically distinct phenomena governing the evolution of the thermal structure. In the spring, the transition is purely convective; the lake convects as sunlight warms water below the temperature of maximum density ($T_{MD}$) on a diurnal basis, and stratifies immediately upon reaching $T_{MD}$. Conversely, in the fall, continuous cooling by turbulent fluxes typically cool the lake past TMD, and stratification only sets in once the lake reaches temperatures between 3.0°C and 3.5°C. When cooling between $T_{MD}$ and the onset of stratification, the process is not convective; rather it must be being driven purely by wind mixing. The rate of cooling during this period, which can last for up to two months, varies significantly from year to year, and is strongly tied to regional air temperature. Once the buoyancy flux is

sufficiently strong to overcome wind mixing, the lake negatively stratifies, with 3.0-3.5°C water locked into the deep portion of the lake, and the surface layer cooling off further.

# B

**Kerrice Bailey**, York University, Toronto, ON, Canada. **Spatial heterogeneity in water quality across the northern nearshore regions of the Great Lakes.**

Millions of people rely on the Laurentian Great Lakes for drinking water, irrigation for agriculture, transportation, and recreational activities. We provide the first comprehensive analysis of spatial heterogeneity in the nearshore regions of the Great Lakes spanning from 2000 to 2019 with a total of 23 water quality variables for 52 nearshore sites. We ask: (1) What is the extent, range, and magnitude of spatial heterogeneity in water quality conditions across the nearshore of the Canadian Great Lakes? and (2) How do land cover, site characteristics, and weather influence water quality conditions? Lakes Erie and Ontario generally had higher concentrations of chloride, chlorophyll a, and nutrients, whereas high silicate concentrations were observed in the northern lakes such as Lake Superior. Consistent patterns of degraded water quality were found in Areas of Concern, highlighting the importance of continued management in the Great Lakes watersheds to promote water quality.

**Adellia Baker**[1] and Rachel Schultz[2], [1]State University of New York Brockport, Brockport, NY, USA, [2]SUNY Brockport Department of Environmental Science and Ecology, Brockport, NY, USA. **Cattail restoration impacts on two grasses in the wet meadow zone in Lake Ontario coastal wetlands.**

Great Lakes coastal wetlands support a diverse community of wet meadow vegetation that is maintained by fluctuating lake levels. These plant communities have been increasingly invaded by hybrid cattail (*Typha* x *glauca*) as higher, more stable lake levels have resulted from water regulation on Lake Ontario. While recent restoration efforts around Lake Ontario have focused on restoring the wet meadow habitat through managing cattail and updating the regulation plan, the effects of these methods on other invasive species (including reed canary grass) have not been fully studied. We will conduct vegetation and soil sampling in 16 wetlands around southern and eastern Lake Ontario and the Upper St. Lawrence River to determine how cattail management impacts the wet meadow zone following water regulation plan change. Three of these wetlands have previously had chemical and mechanical cattail treatments implemented, while the remaining 13 wetlands have not had treatments applied. Additionally, we will conduct a greenhouse study where we will apply five combinations of nitrogen and phosphorus levels to pots with reed canary grass and native Canada bluejoint grass to determine how competition dynamics between these species are impacted by soil nutrient levels. Results of this research could be used by practitioners to guide restoration methods as well as future changes to water regulation to make coastal wetlands more productive and resilient to invasion.

**Anna Baker**[1], Rebecca M Kreiling[2], Carrie Givens[3], Richard L. Kiesling[1], Eric Dantoin[4] and Patrick Perner[4], [1]U.S. Geological Survey Upper Midwest Water Science Center, Mounds View, MN, USA, [2]United States Geological Survey, La Crosse, WI, USA, [3]U.S. Geological Survey Upper Midwest Water Science Center, Lansing, MI, USA, [4]U.S. Geological Survey Upper Midwest Water Science Center, Rhinelander, WI, USA. **From land to lake – tributary nutrient cycling and loads and their role in Lake Superior nearshore algal blooms.**

Lake Superior is among the most oligotrophic of the Great Lakes, however, over the past decade, repeated nearshore cyanobacterial blooms have occurred along the southwestern shore. Previous studies indicate that event-driven nutrient, sediment, and cyanobacteria loading from tributaries may be an important driver of these blooms. To further investigate this, the U.S. Geological Survey participated in a

large multi-institution partnership under the Collaborative Science and Monitoring Initiative. We examined how nutrient and sediment loads from two key tributaries in the vicinity of recurring cyanobacterial blooms, Bois Brule and Siskiwit Rivers, impact nearshore waters. Continuous and discrete water quality and streamflow data collected at gaging stations on these tributaries will be used to develop regression-based models of total nitrogen (TN), total phosphorus (TP), and suspended sediment to nearshore waters. Sediments collected from the water column and streambed were analyzed for phosphorus binding and release, which provides insight into how sediment loading may serve as a temporary sink or long-term source of phosphorus to the nearshore. Preliminary data show TP ranged from below detection (0.006 milligrams-per-liter (mg/L)) to 0.538 mg/L, and TN from below detection (0.05 mg/L) to 2.4 mg/L during this low-flow dominant period. Preliminary findings including spatial and temporal variation in nutrient availability and relationships between concentration and discharge will be presented.

**Vanessa Baker**, Carmody McCalley and Christy Tyler, Rochester Institute of Technology, Rochester, NY, USA. **Impacts of Water Lily Invasion and Removal on Wetland Ecosystem Function.**

Wetlands provide numerous ecosystem services. Despite their importance, disturbances lead to wetlands loss, creating the need for wetland restoration. However, constructed wetlands may fail to replicate services provided by natural wetlands. Colonization by native and non-native invasive plants is considered a primary reason for this failure. We observed formation of monoculture by White Water Lily (*Nymphaea odorata*) in permanently flooded created wetlands in Western New York State. Exclusion experiments demonstrated that herbivores such as waterfowl graze on desired vegetation, decreasing plant diversity, and increasing water lily cover. We subsequently observed a decrease in waterfowl use. To evaluate potential remediation options, in summer 2022 we experimentally removed water lilies in both small and large scale plots and assess impacts on multiple wetland ecosystem functions. Small scale removal plots were crossed with an existing long-term herbivore exclusion experiment. Removing water lilies increased plant diversity during the first growing season. Waterfowl utilization of removal areas was significantly greater than non-removal areas. This research intends to highlight the importance of multiple drivers of ecosystem services, and improve wetland restoration efforts.

**Caroline Barth**, Angelica Vazquez Ortega and Kevin McCluney, Bowling Green State University, Bowling Green, OH, USA. **Cycling of phosphate in farm soils amended with dredged materials: Insights from oxygen isotopes.**

Agricultural fields in northwest Ohio contribute to phosphorus loading in Lake Erie, which can cause harmful algal blooms. Understanding nutrient cycling within soils may yield insight on remediation efforts, including using lake dredged materials (DM) as a soil amendment. One method for observing phosphate cycling is by analyzing the $^{18}O/^{16}O$ ratio of phosphate and water molecules within the soils. Enzymes, such as pyrophosphatase, catalyze the exchange of O in water and phosphate, thus with greater biological processing of phosphate, the $^{18}O/^{16}O$ signature of phosphate may approach an equilibrium with water. We tested the effects of DM amendment on the rate of biological turnover of phosphate in soils growing corn using oxygen isotopes. To use this method, either the phosphate isotope ratio or the equilibrium isotope ratio needs to be altered, and the rate it approaches the isotopic equilibrium is then measured. Two methods were compared: a) addition of inorganic fertilizer to alter the phosphate isotope ratio and b) irrigation with isotopically enriched water to alter the equilibrium isotope ratio. Since DM has been shown to have higher cation exchange capacity and organic carbon content when compared to a Holtville farm soil, it was predicted that DM would increase biological recycling of phosphate, which could improve corn growth and reduce leaching of phosphate from the soil.

**Aman Basu**, Kevin Blagrave, Dawn R Bazely and Sapna Sharma, York University, Toronto, ON, Canada. **Phenological Shifts in Lake Ice across the Northern Hemisphere.**

Ice cover is critical for preserving socio-ecological resilience within lakes owing to the importance of lake ice to limnological processes across seasons and the human dependence on the myriad of ecosystem services that lake ice provides. Long-term records of ice phenology are particularly useful in enumerating the effects of climate change on lakes. This study uses *in situ* lake ice phenological records for a gradient of very small to very large lakes obtained from a vast citizen science network where we have now compiled *in situ* ice phenological records for 2499 lakes across 15 countries for an average of 30 years. These data show that for the last 50 years (1970-2020), the annual mean duration of lake ice cover decreased at a rate of 7.2 days per decade, with an acceleration in ice loss after 1988/1989. A combination of meteorological and morphological variables explained 75% of the variation in ice-on dates and 85% of the variation in ice-off dates. Now that these models have been validated, we will use them to forecast future changes in the lake ice cover for 1.2 million Northern Hemisphere lakes until 2100 using the most recent shared socioeconomic pathways (SSPs) climate scenarios.

**Nandita Basu**, University of Waterloo, Waterloo, ON, Canada. **Nutrient legacies: the critical role of the subsurface in addressing surface water pollution.**

Excess nitrogen (N) and phosphorus (P) inputs from agricultural and urban sources have contributed to the eutrophication of rivers and lakes, both globally and within the transboundary Laurentian Great Lakes Basin (GLB). Despite widespread efforts to reduce P inputs within the GLB, the last decade has seen an increase in eutrophication and algal blooms. While eutrophication in Lake Erie has received the most attention, blooms have also been increasing in smaller lakes and reservoirs across the basin, threatening ecosystems, drinking water supplies, and lake-dependent tourism economies. Such apparent failures can be attributed in part to legacy nutrients that have accumulated over decades of agricultural intensification and that can lead to time lags in water quality improvement. In this talk, I will use a combination of data synthesis, process and machine learning models to quantify the drivers of nutrient pollution in the GLB, with special focus on quantifying the role of subsurface processes in surface water pollution.

**Evan Batte**[1], **Nicole Fuller**[1], Paige Arieno[1], Jayson Kucharek[1], Steven Day[1], Nathan C Eddingsaas[2], Matthew Hoffman[1], Andre Hudson[1] and Christy Tyler[1], [1]Rochester Institute of Technology, Rochester, NY, USA, [2]School of Chemistry and Materials Science, Rochester Institute of Technology, Rochester, NY, USA. **Accumulation and degradation of debris in the watershed of Lake Ontario.**

Anthropogenic debris is a major environmental pollutant with significant implications for environmental and human health in the Great Lakes region. Estimates of debris input to the Great Lakes often assume that land-derived material is transported rapidly downstream. However, environmental filters, such as stormwater retention ponds and riparian zones, can act as temporary or permanent repositories, reducing debris loading in the Lakes and creating hotspots of accumulation across the landscape. We isolated, quantified, and identified (using FT-IR) micro (<5 mm) and macro (>5 mm) debris accumulation seasonally in stormwater ponds and riparian areas across a rural to urban gradient in the watershed of the Rochester Embayment of Lake Ontario. We also deployed a long-term experiment in riparian areas, stormwater ponds and roadside catch basins to field-age the most commonly collected debris items: cigarette butts, polypropylene-metal chip bags, and polyethylene shopping bags. We present characterization of debris degradation from early samples of the experiment by measuring tensile strength, degree of oxidation and biofilm development. Ultimately, these experiments will aid in estimating debris turnover in each hotspot environment and closing the gap on debris sources and sinks in the Great Lakes Basin.

**Karen A. Baumann**[1], Harvey A. Bootsma[1], Doug Bradley[2], Erika Jensen[3], Tyler Alexander Kunze[1], Brenda Lafrancois[4] and Benjamin Turschak[5], [1]University of Wisconsin-Milwaukee, Milwaukee, WI, USA, [2]LimnoTech, Ann Arbor, MI, USA, [3]Great Lakes Commission, Ann Arbor, MI, USA, [4]National Park

Service, Ashland, WI, USA, [5]Michigan Department of Natural Resources, Charlevoix Fisheries Research Station, Charlevoix, MI, USA. **Success and consequences of multiple methods of small-scale dreissenid mussel removal.**

Dreissenid mussels have transformed Great Lakes ecosystem structure and function, but few studies have examined the feasibility or consequences of their removal. We report findings from small-scale experimental mussel removal projects at three 10-m-deep nearshore sites in Lake Michigan, two near Sleeping Bear Dunes National Lakeshore and one near Milwaukee. Mussels were removed using three techniques: manual scraping, a 26-day deployment of benthic barrier membranes, or an eight-hour application of a molluscicide (Zequanox®) beneath benthic containment enclosures. Mussel mortality was 100% for manual scraping and barrier membranes. Molluscicide treatment yielded 63% mortality in caged mussel enclosures and 97% on natural substrate. Non-target benthic invertebrates also largely disappeared from all mussel removal sites. Long-term efficacy was variable between treatments with 5.7% mussel recolonization (370 mussels/$m^2$) at manually scraped sites six years post-treatment relative to control densities (6500 mussels/$m^2$). Molluscicide-treated sites experienced 36% recolonization (1800 mussels/$m^2$) one year post-treatment relative to control (5000 mussels/$m^2$). Experiments conducted with Hester-Dendy traps near removal sites suggest that predation by round gobies may be the mechanism for sustained post-removal mussel suppression. Results of these studies suggest removal of dreissenids at ecologically relevant scales may be feasible, but the persistence of treatment effects and consequences for other benthic biota must be examined further.

**Sam Beck-Andersen**, Kathryn Monacelli, Josh Neff, Trevor Massey and Lisa B. Cleckner, Finger Lakes Institute - Hobart and William Smith Colleges, Geneva, NY, USA. **Hydrilla verticillata in the Finger Lakes: Using monitoring and collaboration to inform mitigation efforts.**

The introduction and spread of aquatic invasive species (AIS) such as Hydrilla (*Hydrilla verticillata*) significantly threaten the Great Lakes basin. Listed by the Council of Great Lakes Governors as a 'least wanted' plant, Hydrilla can spread quickly, impacting water quality, fish habitat, recreation, irrigation, and hydropower generation. Climate change may enhance habitat suitability and the impacts of monoecious Hydrilla found in the Great Lakes if understudied. Many stakeholders across the Finger Lakes have been cooperating on a regional and state effort to control Hydrilla in Cayuga Lake, the second largest Finger Lake. Cayuga Lake is part of the Lake Ontario watershed and is hydrologically connected to the Great Lakes via the Seneca and Oswego Rivers. Finger Lakes Institute staff members have collected water quality and hydroacoustic data and performed macrophyte surveys focused on Cayuga and the greater Finger Lakes region over the last three years. Analyses of annual macrophyte density and community composition show few, small isolated populations of Hydrilla outside of areas treated by dredging and herbicide application. Comparisons of macrophyte communities near treatment sites and the identification of vulnerable areas for future infestations will be presented. Finally, recommendations for early detection and rapid response will be made based on the physical characteristics of Cayuga Lake and the people using Cayuga Lake for recreational activities and angling.

**Timothy Becker**, Cuyahoga Soil and Water Conservation District, Cleveland, OH, USA. **The First Rings First Fellowship: Facilitating student-centered watershed investigations.**

The First Rings First Fellowship (FRFF) empowers youth from historically underserved communities to identify problems in their watershed and enact solutions. Created by educators at Cuyahoga Soil & Water Conservation District (CSWCD) with funding from Bay Watershed Education and Training (B-WET), the FRFF brought together educators and resource professionals to facilitate student-centered investigations and action projects. To reach underserved students, we recruited teachers from the First Ring Schools Collaborative, a regional association of school districts that addresses the challenges faced by students living in poverty. We incentivized participation with immersive professional development, professional grade research equipment and stipends. Teachers had opportunities to connect with regional

environmental education facilities, get certified in environmental curricula, and learn student-centered inquiry techniques like the Question Formulation Technique (QFT). We engaged students in developing their own questions about their watershed using the QFT, connected them to opportunities to investigate their questions, and supported them as they planned action projects, many of which address the impacts of a changing climate. Students will present their investigations and action projects at a symposium this spring.

**Nina Beigzali**[1], Leon Boegman[1], Yingming Zhao[2] and Josef D. Ackerman[3], [1]Environmental Fluid Dynamics Laboratory, Department of Civil Engineering, Queen's University, Kingston, ON, Canada, [2]Aquatic Research and Monitoring Section, Ontario Ministry of Natural Resources and Forestry, Lake Erie Fishery Station, Wheatley, ON, Canada, [3]Department of Integrative Biology, University of Guelph, Guelph, ON, Canada. **Three-dimensional simulation of walleye habitat in Lake Erie for management of quota allocation.**

Lake Erie's fishery management strategies have played an integral role in restoring valuable native fish species as the lake has been severely impacted by multiple stressors over the past decades. Adaptive management strategies considering climate change implications on native fish species are inevitable, even though present management guidelines continue to implement the approach of apportioning quota based on static habitat distributions, defined as the proportion of lake area less than 13 m deep in each jurisdiction. The present study aims to dynamically compute walleye habitat as a function of the water quality distributions (temperature and dissolved oxygen) simulated using a three-dimensional (ELCOM-CAEDYM) hydrodynamic-ecological model. The modelled habitat distributions were validated against commercial walleye distribution collected by the Ontario Ministry of Natural Resources and Forestry (OMNFR) for the year 2008, comparison between the gillnet observations and the habitat distribution was conducted based on the nearshore vs. offshore walleye distribution as well as assessing the accuracy performance of each habitat definition in predicting the walleye movement patterns in the water column. The validated model was then used to predict the habitat distribution in response to changing temperatures and dissolved oxygen concentrations under climate change scenarios. The findings can be used as a guideline to refine habitat vs stock models for walleye quota allocation within each jurisdiction.

**Ashley J. Belle**, Illinois-Indiana Sea Grant, Chicago, IL, USA. **Diversifying outreach to increase knowledge of a Great Lakes Legacy Act sediment remediation project.**

Under the Great Lakes Legacy Act program, over 400,000 cubic yards of contaminated sediments were remediated in the Spirit Lake area near the Morgan Park community of Duluth, Minnesota. Remediation of the site will result in aquatic ecosystem improvement and will contribute towards the larger effort of delisting the St. Louis River Area of Concern. To support the project's goal of having timely, consistent, and appropriate messaging, a Community Involvement Plan (CIP) was developed to identify the local community and key project stakeholders and to outline the community outreach engagement strategy. The CIP ensured the creation of a diversified outreach team composed of individuals from federal, state, and local agencies, community organizations, environmental groups, and the surrounding neighborhood. The outreach team met regularly to guide the design and delivery of outreach, which consisted of public events, posters, community kiosks, weekly photo galleries, fact sheets, and neighborhood notifications. To gauge the impact of these outreach efforts, surveys were distributed to the community and analyzed. Results revealed that the scientific information provided was understandable and increased knowledge of the project. While public events ranked highest as the preferred mode of receiving information, respondents liked the diversity of outreach tools and indicated that they met a variety of different needs. This outreach work can serve as a model for other projects to create diverse outreach teams and tools to engage surrounding communities.

**Rene Belleville** and Rachel Schultz, SUNY Brockport Department of Environmental Science and Ecology, Brockport, NY, USA. **Assessing establishment of native species in a restored Great Lakes coastal wetland invaded by *Typha x glauca*.**

Coastal wetlands within the Great Lakes have been altered by the invasion of *Typha x glauca*, hybrid cattail, especially native meadow marsh communities. Cranberry Pond on the southern shore of Lake Ontario, was restored by excavating channels and open water areas within dense *Typha* stands and spreading the spoils to create mounds at the appropriate elevation to support meadow marsh vegetation. Our objective was to test survivorship of two native meadow marsh species subject to different seeding/planting treatments at Cranberry Pond using a randomized block design field experiment. We chose Canada bluejoint, *Calamagrostis canadensis*, and lake sedge, *Carex lacustris*, as study organisms due to their significance in native meadow marsh communities. We set up treatment plots within 12 mounds (blocks) including plots that were seeded (Seed), seeded then covered with hay (Hay), planted with plugs (Plugs), control, and reference plots. We collected vegetation cover data and measured soil moisture for each plot in summer 2022. Both species showed differences in percent cover for each treatment with *C. canadensis* having the highest cover in Seed plots and *C. lacustris* in Plug plots. Our results after the 2023 field season will help managers make informed decisions on seeding and planting methods for restoring meadow marsh communities.

**Laura R Benakoun**[1], Janis L Thomas[1], Grace Arabian[1], Derek Smith[1], Christopher Wellen[2] and Ryan J Sorichetti[1], [1]Ontario Ministry of the Environment, Conservation and Parks, Toronto, ON, Canada, [2]Toronto Metropolitan University, Toronto, ON, Canada. **Multi-Watershed Nutrient Study: Challenges and potential of a high-frequency monitoring network.**

The Multi-Watershed Nutrient Study (MWNS, 2015 – 2020), led by Ontario Ministry of the Environment, Conservation and Parks, encompassed seasonal baseflow and flow event sampling, inclusive of nutrient chemistry, *in situ* high-frequency water temperature and turbidity as well as local meteorological information for 11 agricultural watersheds in southern Ontario. Challenges, insights and successes of a high frequency 4 season water quality monitoring network will be discussed. Comparisons of MWNS sites that were also monitored in the 1970s have identified changes in flow and nutrient concentrations and emphasized the need for winter and full hydrograph event sampling. The use of MWNS data has led to the development of more flexible generalized additive models for nutrient loadings and has helped quantify the importance of extreme runoff events to annual nutrient loads. Core MWNS data have also been leveraged by partners by using stable isotope analysis to better model the sources of stream water and non-point nutrients and to improve the modelling of baseflow in nutrient models. The selection of MWNS sites to be representative of potential nutrient loss ranges over the agricultural land uses in southern Ontario allows assessment of the effects of land use and land management on nutrient export in agricultural headwaters.

**Jordanna Bergman**[1], Joseph Bennett[1], Valerie Minelga[2], Chantal Vis[3], Aaron Fisk[4] and Steven Cooke[1], [1]Carleton University, Ottawa, ON, Canada, [2]Parks Canada, Peterborough, ON, Canada, [3]Parks Canada, Gatineau, QC, Canada, [4]School of the Environment, University of Windsor, Windsor, ON, Canada. **An Interdisciplinary Evaluation of Native and Invasive Fish Connectivity in a Navigational Waterway.**

Interconnected freshwater systems, like artificial waterways, are now pervasive globally and have facilitated countless invasions. Most waterways are linked by barriers (e.g., lockstations), providing an opportunity to selectively restrict invasive fish without negating connectivity to native species. However, the ecological connectedness across a waterway is often unknown, make it difficult to apply selective fragmentation efforts. Here, we blended acoustic telemetry (native largemouth bass & northern pike, and invasive common carp; N=225) and mark-recapture (15 species; N=9563) data with operation and biotic data to evaluate barrier passability at ten lockstations over five years (2018-2023) in the Rideau Canal Waterway. This 202-km navigable route forms a hydrological link between the Ottawa River and Lake Ontario, connected by 23 lockstations. Our results suggest barriers minimize, but not entirely restrict,

connectivity. We documented 36 passage events by 26 native fishes at nine lockstations, mostly in the spring. No common carp passages were detected; movements indicated carp favoured high-flow areas downstream of dams, regions with no pathway upstream. Passages were recorded in all years, except 2020 – the year of global COVID-19 lockdowns – implying potential "anthropause" effects. We discuss consequences of season-, direction-, and species-specific passages, and other fish interactions with infrastructure. Our work informs evidence-based management planning to support conservation actions in North American waterways and beyond.

**Ryan D Bergstrom**, University of Minnesota-Duluth, Duluth, MN, USA. **Community capacity and climate change in the Laurentian Great Lakes Region.**

The Laurentian Great Lakes region in North America is experiencing climate-driven disturbances that threaten the public safety of the region and is forcing communities to respond. Communities vary in their ability to respond to these disturbances based on their existing capacities and access to resources, but responses in the region are uneven and create vulnerabilities to disasters. A virtual workshop was conducted to understand the community responses to climate-driven disturbances in the Great Lakes and identify the essential capacities for effective responses. Results show that the region as a whole has not responded adequately, community complacency is prevalent, and although the resources exist to respond, they are not adequately organized. In addition, results suggest that inequalities between urban and rural communities are exacerbating these challenges. Community capacities identified as critical for resilience include leadership, scientific knowledge, and connection to broader regional networks to access additional resources.

**Nicole Lynn Berry**[1], David B. Bunnell[2], Erin P. Overholt[1], Jennifer Schumacher[1], Kevin Keeler[2], Jason Smith[3], Kristopher Dey[4], Steve Pothoven[5], Brian C. Weidel[6], Roger Gordon[7], Addison A. Zeisler[1] and Craig E. Williamson[1], [1]Miami University, Oxford, OH, USA, [2]USGS Great Lakes Science Center, Ann Arbor, MI, USA, [3]Sault Ste. Marie Tribe of Chippewa Indians, Sault Ste. Marie, MI, USA, [4]Little Traverse Bay Bands of Odawa Indians, Levering, MI, USA, [5]NOAA GLERL, Muskegon, MI, USA, [6]USGS Great Lakes Science Center, Oswego, NY, USA, [7]US Fish and Wildlife Service, Jordan River National Fish Hatchery, Elmira, MI, USA. **Anyone need sunscreen? Comparing the UV-tolerance and risk of UV-exposure among coregonine species.**

Ultraviolet radiation (UV) can penetrate as deep as 10 m in offshore Lakes Michigan and Huron and even to the bottom in nearshore beaches. In other highly transparent lakes, UV has been shown to be lethal to both fish eggs and larvae. In the Great Lakes, well-documented increases in water transparency may have increased UV exposure and contribute to fish recruitment declines. Key information gaps for many species include UV-tolerance or mechanisms of protection like photo-enzymatic repair (PER) in DNA. Since 2019, we have quantified the UV-tolerance and tested for evidence of PER in Lake Michigan stocks of Lake Whitefish (Adikameg in Ojibwe; *Coregonus clupeaformis*), Cisco (Otoonapi in Ojibwe; *C. artedi*), and Bloater (*C. hoyi*). For Cisco, we also evaluated additional stocks from Lakes Huron and Ontario, and a less transparent inland lake in Minnesota. The UV-tolerance of coregonine species positively correlated with the water transparency at a reproductive site in Lake Michigan. Conversely, Cisco from less transparent Lake Ontario and Koronis Lake (MN), had a higher UV-tolerance than Lakes Michigan or Huron stocks. Finally, we found the eggs of coregonines, typically incubating under the ice, had a higher UV-tolerance than larvae. Evidence of PER was not observed in eggs but was for most larval fish species. Our results support UV as a potential regulator of Great Lakes fish recruitment, especially shallow spawning coregonines such as Lake Whitefish.

Ken G Drouillard[1], **Satyendra Bhavsar**[2], Nadine Benoit[3], Don Little[4] and Laud Matos[5], [1]Great Lakes Institute for Environmental Research, University of Windsor, Windsor, ON, Canada, [2]Ontario Ministry of Environment, Conservation and Parks, Toronto, ON, Canada, [3]Ministry of the Environment, Conservation

and Parks, Toronto, ON, Canada, [4]Watershed Planning and Ecosystem Science, Toronto and Region Conservation Authority, Vaughan, ON, Canada, [5]Environment and Climate Change Canada, Toronto, ON, Canada. **Assessment of the fish consumption beneficial use (BU #1) in the Toronto and Area AOC.**

The fish consumption beneficial use (BU #1) was assessed for the Toronto and Region Area of Concern. The revised assessment adopted a 4-tier framework for BU#1 to accommodate new data from angler surveys, new records of fish contamination and consider temporal trends of fish and environmental contamination, fish residency status and clean-up actions taken. Angler surveys were used to select indicator species and generate species specific unrestricted consumption benchmarks. Tier 1, comparing monthly meal advice against unrestricted benchmarks, and Tier 2, comparing monthly restrictions in the AOC versus reference, failed for 6 of 13 indicator species. Tier 3, which uses a weight of evidence approach to address spatial and temporal patterns of fish contamination, passed for 4 of the 6 species failing Tier 2 but continued to fail for Rainbow Trout and White Sucker. Tier 4 applied a second weight of evidence approach to consider trends in environmental contamination, completed clean-up activities, young-of-the-year (YOY) forage fish and indicator fish species residency status. Rainbow trout, had limited recent contaminant data and is designated as a non-resident species to the AOC with little likelihood of improvement as a result of further cleanup. For white sucker, only fish the largest size class (>55 cm) failed the Tier 3 criteria. However, the residency status of this species was less clear. The majority of Tier 4 evidence lines were supportive of delisting the use impairment from impaired to unimpaired.

**Bopi A. Biddanda**[1], Ian P. Stone[2], Janie C Cook[3] and Tony D. Weinke[3], [1]Grand Valley State University, Muskegon, MI, USA, [2]University of Michigan, Ann Arbor, MI, USA, [3]Grand Valley state University, Muskegon, MI, USA. **The 1 mm Journey: Diel vertical migration in extant microbial mats optimizes oxygenation.**

Modern-day benthic microbial mats, resembling those of early Earth, inhabit Lake Huron's low-oxygen, high-sulfur, groundwater-fed submerged sinkholes. Here, we gathered time-lapse images of alternating waves of vertically migrating filamentous photosynthetic cyanobacteria and chemosynthetic sulfur oxidizing bacteria responding to daily fluctuating sunlight and chemical gradients, turning the mat surface visibly purple during day and white at night, respectively. We also gathered time-series microprofiles of dissolved oxygen and hydrogen sulfide at 100μm and 200μm intervals across the water-mat-sediment interface over a diel cycle which suggested oxygen is generated within the mat during day and hydrogen sulfide seeps out of the mat into the overlying water at night. These results suggest that cyanobacteria rise to the top of the mat to harvest sunlight during the day and sulfur oxidizing bacteria rise during the night in step with the vertically moving $O_2/H_2S$ gradient. Such modern day synchronized diel migration might have been the first and largest daily mass movement of life during the long Precambrian. During that time, microbial mat motility would have played a critical role in metabolism optimization across a tiny but sharp redox gradient in the benthic mat world, eventually oxygenating the biosphere.

**Yvonne Bigengimana**, Albertine Rift Conservation Society, Kigali, Rwanda. **Bioassessment of water quality using benthic macroinvertebrates as bioindicators in Akagera River in Rwanda.**

Every living organism needs fresh and clean water to survive. Particularly benthic macroinvertebrates are critically affected by changes in water quality. The main purpose of this study is to **assess the quality of Akagera river and wetland freshwater ecosystem using macroinvertebrates as bioindicators**. The Akagera river is a transboundary ecosystem that flows into Lake Victoria. I assessed the distribution and abundance of aquatic macroinvertebrates in the rivers that enter Akagera and Akagera river itself that forms the upper Akagera river and wetland freshwater ecosystem in the eastern part of Rwanda. Data were collected within four main sites including two sites on Akanyaru and Nyabarongo rivers, and two sites on Akagera river and surrounding wetland for benthic macroinvertebrate assemblages and physico-chemical parameters including pH value, conductivity, temperature, and water speed. Riparian land use types were also recorded with focus on natural vegetation and agriculture. Collected macroinvertebrates were

conserved in labelled containers with 96% ethanol solution and taken to the Zoological Collection laboratory at the University of Rwanda, and later identified to the family level using the identification keys. A total of 1920 specimens were collected, of which 1865 macroinvertebrates individuals were identified and grouped into 5 classes, 10 orders, and 21 families. The results revealed that Akagera river and the surrounding wetland are dominated by macroinvertebrates that are highly tolerant to water pollution.

**Caren Binding**, Chui Zeng, Larissa Pizzolato, Colleen Booth, Reza Valipour, Phil Fong, Arthur Zastepa and Tim Pascoe, Environment and Climate Change Canada, Burlington, ON, Canada. **Satellite-derived algal bloom indices on Lake of the Woods; bloom status, trends, and drivers.**

Despite significant declines in external phosphorus loads, Lake of the Woods continues to experience severe recurring cyanobacterial harmful algal blooms (cHABs) covering as much as 80% of the lake surface area. Satellite-derived bloom indices were used to assess the status, trends, and drivers of cHAB conditions for the period 2002 to 2021 in support of developing ecosystem objectives and response indicators for the lake. Areas of greatest potential concern, with the most prolonged bloom occurrences, were in the southeast of the lake. Significant decreases in bloom indices suggest the lake may now be responding to historical nutrient reductions. The greatest rates of decrease were within the main water flow paths, with little change in the more isolated embayments, suggesting flushing plays a key role in regulating regional bloom severity. Significant inter-annual variability in bloom phenology was observed, with blooms peaking later in recent years, which may be in response to climate-induced changes in the lake and watershed. The absence of a direct relationship between external phosphorus loads and annual bloom severity reflects the complexity of the lake's response to eutrophication and the potential roles of other drivers including climate and a strong legacy effect of sedimentary nutrients. A case study of the 2017 bloom season captures the compounding interaction of meteorological variability and seasonal nutrient delivery in regulating the bloom response.

**Hannah Blair**[1], Lars G. Rudstam[2], Kayden C Nasworthy[2], James M Watkins[2], Anne E Scofield[3], Thomas M Evans[1], Suresh A. Sethi[1], David M Warner[4], Daniel L Yule[5] and Peter C Esselman[4], [1]Cornell University, Ithaca, NY, USA, [2]Cornell Biological Field Station, Bridgeport, NY, USA, [3]US Environmental Protection Agency, Chicago, IL, USA, [4]U.S. Geological Survey, Great Lakes Science Center, Ann Arbor, MI, USA, [5]U.S. Geological Survey, Lake Superior Biological Station, Ashland, WI, USA. **Insights into scattering layer identity using dual frequency acoustics in the Great Lakes.**

Acoustic backscattering strength (Sv) depends not only on biomass but also on the size of the animals insonified. The length dependence is related to the relative length of the sound wave and the animals and is highly dependent on the frequency of sound used. This relationship is non-linear, and smaller organisms have substantially lower acoustics backscattering at lower frequencies (=i.e., shorter wavelengths) compared to larger organisms. Marine acousticians use the difference in backscattering at different frequencies to infer the identity of the organisms in the scattering layers. The taxonomically less complex zooplankton community in Great Lakes should lend itself even better to this approach than the highly diverse oceans. Here we present examples from several data sets to explore the ability of Sv differencing to identify and separate fish, mysids and larger zooplankton in the Great Lakes. Acoustic returns from both ships and unmanned vehicles were compared with data from Optical Plankton Counters and net tows. Sv differencing using 120 and 430 kHz data provided distinct signatures for zooplankton, mysid, and fish layers. Increased future use of multifrequency unmanned acoustic data collection systems will increase our ability to predict distribution and migrations of different zooplankton groups.

**Emma J Bloomfield** and Timothy B Johnson, Ontario MNRF, Glenora Fisheries Station, Picton, ON, Canada. **Long-term temporal variation in the isotopic niche of three species of salmonids in Lake Ontario.**

Understanding how species and ecosystems respond to ecological changes, such as altered nutrient availability and invasive species, is critical for successful resource management. Investigating isotopic niches through time can provide baseline trophic information and reveal species and system responses. Stable isotope analysis of archived tissue provides a unique opportunity to retroactively study trophic niches. We conducted carbon and nitrogen stable isotope analysis on scales from Lake Ontario lake trout (*Salvelinus namaycush*), Chinook salmon (*Oncorhynchus tshawytscha*), and rainbow trout (*O. mykiss*) over five decades. We characterized the isotopic niches during five ecological stanzas: pre-phosphorous control, phosphorous control, dreissenid (*Dreissena* spp.) invasion, round goby (*Neogobius melanostomus*) invasion, and alewife (*Alosa pseudoharengus*) decline, revealing long-term changes in trophic ecology. The $\delta^{13}C$ signature of all three species increased (indicating more nearshore energy use) after dreissenid invasion and $\delta^{15}N$ decreased (indicating lower trophic position) through time. The greatest decline in $\delta^{15}N$ was observed for lake trout after round goby invasion. Isotopic niche overlap between some species was higher in recent ecological stanzas, concurrent with a decline in the salmonid community carbon range. Overall, Lake Ontario salmonid isotopic niches have changed through time, with a lower diversity of basal carbon resources utilized resulting in high (>60%) isotopic niche overlap between species in some cases.

**Serghei A. Bocaniov**[1], Kevin G. Lamb[2], Yerubandi R. Rao[3] and Philippe Van Cappellen[4], [1]Department of Earth and Environmental Sciences, Ecohydrology Group, University of Waterloo, Waterloo, ON, Canada, [2]Applied Mathematics, University of Waterloo, Waterloo, ON, Canada, [3]Environment and Climate Change Canada, Burlington, ON, Canada, [4]Ecohydrology Research Group, University of Waterloo, Waterloo, ON, Canada. **Thermal structure and bottom water hypoxia of a large lake: Sensitivity to climate change.**

Air temperature (AT) and wind speed (WS) modulate the seasonal timing, duration and strength of mixing and stratification in lakes. Global climate change is expected to not only alter AT but also wind energy. Nonetheless, the predictive understanding of the relationships between climate change induced stressors (especially AT and WS) and the expected in-lake responses remains uncertain. Here, we apply a 3-dimensional coupled hydrodynamic-ecological model to the central basin of Lake Erie to analyze how sensitive the thermal structure and dissolved oxygen (DO) distribution during the ice-free period are to variations in TA, WS, and combinations of the two. To this end, we derive predictive climate change impact – ecosystem response relationships that allow us to simulate the intensity and duration of water column stratification and the accompanying extent of bottom water hypoxia (DO < 2 mg $L^{-1}$) and anoxia (DO < 1 mg $L^{-1}$) under ongoing and anticipated trends in AT and wind speed in the Lake Erie basin.

**Georgia Bock**[1], Leigh J. McGaughey[1], Mary Ann C. Perron[1], Dale Phippen[2], Patricia O'Hara[2] and Jeff J. Ridal[1], [1]St. Lawrence River Institute, Cornwall, ON, Canada, [2]Great River Network, Cornwall, ON, Canada. **Community Involvement Critical for Revitalization: A Case Study in the Upper St. Lawrence River.**

The Great River Network, which brings together over 50 environmental community groups and organizations, has played a key role in facilitating the remediation and restoration of the Upper St. Lawrence River. Community engagement, initiated as part of the Remedial Action Plan for the Area of Concern at Cornwall/Akwesasne/Massena, was formalized in response to a perceived lack of agency and capacity within local communities to respond to new environmental pressures. As a grass-roots initiative, the Great River Network has successfully completed a number of significant remediation and restoration actions; including a series of large-scale river clean ups, fish habitat restoration initiatives, and projects to address the issue of shoreline erosion. Success has been achieved by coordinating action across an extensive network of partners and showcasing how remediation and restoration led by, and embedded in, the community can result in mutually reinforcing social and environmental revitalization. This case study highlights the transformational opportunities that remediation and restoration initiatives can create. In this instance, a highly local initiative has also laid the foundation for moving towards a collective impact approach for the larger region.

**Anna Boegehold**[1], Casey M Godwin[1], Ashley Burtner[1], Danna Palladino[2], Duane Gossiaux[2], Christine Kitchens[1], Paul DenUyl[1], Kelly McCabe[1], Andrew Camilleri[1], Holly Kelchner[1], Glenn Carter[1], Lacey Mason[2], Henry A. Vanderploeg[2], Thomas H. Johengen[3], Dack Stuart[4], Deanna Fyffe Semenyuk[5] and Reagan M. Errera[2], [1]Cooperative Institute for Great Lakes Research, University of Michigan, Ann Arbor, MI, USA, [2]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, USA, [3]University of Michigan, Ann Arbor, MI, USA, [4]Woods Hole Group, Inc., Bourne, MA, USA, [5]Jacobs, Dallas, TX, USA. **10 years of western Lake Erie water quality monitoring data from NOAA GLERL and CIGLR.**

The western basin of Lake Erie has a history of recurrent cyanobacterial harmful algal blooms (HABs) despite decades of efforts between the United States and Canada to limit nutrient loading, a major driver of the blooms. In response, the National Oceanic and Atmospheric Administration (NOAA) Great Lakes Environmental Research Laboratory (GLERL) and the Cooperative Institute for Great Lakes Research (CIGLR) created an annual sampling program to detect, monitor, assess, and predict HABs in western Lake Erie. Here we describe the data collected from this monitoring program from 2012-2021. This dataset includes observations on physico-chemical properties, major nutrient fractions, phytoplankton pigments, microcystins, and optical properties for western Lake Erie. This dataset is particularly relevant for creating models, verifying and calibrating remote sensing, and conducting experimental research to further understand the water quality dynamics that enable HABs in this internationally significant body of freshwater. The dataset can be freely accessed from NOAA National Centers for Environmental Information (NCEI) at https://doi.org/10.25921/11da-3x54.

**Jose L Bonilla-Gomez**[1], Kevin N McDonnell[1], Adam Kowalski[1], Daniel Cunnane[1], Ethan Buchinger[1], Signe VanDrunen[1], Roger Gordon[2], Keith Duffton[3] and Scott R Koproski[1], [1]US Fish and Wildlife Service, Alpena Fish and Wildlife Conservation Office, Alpena, MI, USA, [2]US Fish and Wildlife Service, Jordan River National Fish Hatchery, Elmira, MI, USA, [3]US Fish and Wildlife Service, M/V Spencer F. Baird, Cheboygan, MI, USA. **Survival and reproductive success of cultured cisco (*Coregonus artedi*) in Saginaw Bay, Lake Huron.**

Saginaw Bay historically contained one of the largest spawning aggregations of spawning Cisco (*Coregonus artedi*) within Lake Huron. However, present-day research suggests Cisco have largely been extirpated from Saginaw Bay due to overfishing and introduced species. In 2018 the U.S. Fish and Wildlife Service began stocking approximately 1 million fingerling Cisco in Saginaw Bay annually in an effort to restore Cisco populations to the main basin of Lake Huron. All fingerlings were released in spring and fall events and were differentially marked using Oxytetracycline (OTC) prior to stocking. The goals of this study are to assess the extent to which cultured Cisco survive to maturity, determine if cultured Cisco will return to Saginaw Bay to spawn, and evaluate if they are able to successfully reproduce. We used targeted surveys to collect hatchery and wild origin age-0 and juvenile Cisco in 2019, 2021 and 2022. Several larval Ciscoes were detected (pending genetic confirmation), but overall larval Coregonine production was low in Saginaw Bay. We found only one juvenile in 2021, however in 2022 seven juveniles were detected. Fall gillnet surveys detected 3 hatchery origin spawning adults in 2021 and in 2022 a total of 51(47 hatchery origin and four wild) spawning adults were detected. The OTC analysis showed 85.4% of the specimens were spring release, 6.5% were fall release, and 8.1% wild. These initial results suggest cultured Cisco can survive and spawn in Saginaw Bay, however it is yet to be determined if they can produce viable recruits.

**Arthur Bonsall**[1], Dak de Kerckhove[2], George Morgan[2], Ryan Beach[3], Blair Wasylenko[3], Henrique Giacomini[2] and Darren Smith[2], [1]Ontario Ministry of Natural Resources and Forestry, Port Dover, ON, Canada, [2]Ontario Ministry of Natural Resources and Forestry, Peterborough, ON, Canada, [3]Ontario Ministry of Natural Resources and Forestry, Thunder Bay, ON, Canada. **Predator assemblage influences the maximum size of Cisco (Coregonus artedi) in Ontario inland lakes.**

Cisco (*Coregonus artedi*) have been shown to exhibit notable differences in body size and morphology between lake systems. The goal of this project was to identify factors that influence the maximum attainable

size of Cisco in Ontario inland lakes. Using Generalized Linear Models, we compared the life-history of Cisco between 214 lakes, analyzing a suite of abiotic and biotic predictors. The adjusted maximum length of Cisco (Lmax) was affected by total dissolved solids, Secchi depth, and the interaction between predator assemblage and lake shape. There was no notable effect of effective fetch, a predictor of wind-driven current formation, on Cisco Lmax. When instantaneous mortality (Z) was assessed, the top model included Secchi depth and the interaction between predator assemblage and Z. The Lmax of Cisco was consistently lower in lakes where Lake Trout (*Salvelinus namaycush*) are the only major predator compared to lakes where Walleye (*Sander vitreus*) are present or where both predators cooccur. The results of this study suggest that Walleye exert stronger positive selection pressure on Cisco growth compared to Lake Trout.

**Harvey A. Bootsma** and Nathan Van Ee, University of Wisconsin-Milwaukee, Milwaukee, WI, USA.
**Riverine loading and dreissenid recycling of phosphorus in the Lake Michigan nearshore zone.**

Dreissenid mussels are known to have significantly altered internal phosphorus dynamics in Lake Michigan and other Great Lakes. Less well understood is how these mussels may affect the fate of particulate phosphorus as it enters the lake from rivers. To address this question, we monitored the quantity and forms of phosphorus entering Lake Michigan from two major tributaries, one from a predominantly agricultural watershed and the other from a more developed watershed. River P load was up to 75% particulate P and up to 39% bioavailable P (NaOH-extractable). Much of the bioavailable P was associated with the fine-grained fraction. Experiments conducted with sediments collected in the lake nearshore zone revealed that the fine-grained sediment fraction has the capacity to rapidly adsorb and desorb dissolved P, depending on ambient dissolved P concentration. When fed to quagga mussels, 40% of the P in fine-grained sediment was recycled as dissolved P, whereas <10% of algal P fed to mussels was recycled as dissolved P. These results indicate that fine-grained sediments play a large role in the transport and recycling of P within the nearshore zone, and their role as a source vs sink of dissolved P depends in part on whether they are consumed by dreissenids.

**Justin Bopp**[1], Kelly Filer Robinson[2], Lucas Nathan[3], Seth Herbst[3], Travis Brenden[1], Christine Mayer[4] and John Dettmers[5], [1]Quantitative Fisheries Center- Michigan State University, East Lansing, MI, USA, [2]U.S. Geological Survey, Georgia Cooperative Fish and Wildlife Research Unit, Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA, USA, [3]Fisheries Division, Michigan Department of Natural Resources, Lansing, MI, USA, [4]Department of Biology, Toledo, OH, USA, [5]Great Lakes Fishery Commission, Ann Arbor, MI, USA.
**Re-evaluating an adaptive management framework for invasive grass carp (*Ctenopharyngodon idella)* within Lake Erie.**

Invasive species response requires making decisions under uncertainty, but can be reduced under iterative processes, taking advantage of new research on the species or ecosystem. Invasive grass carp in Lake Erie provides a case study of how uncertainty reduction influenced response strategy selection in an iterative adaptive management (AM) process. In the first iteration of AM: 1) objectives were identified (fulfill public trust, minimize management costs, and minimize collateral damage), 2) grass carp abundance under different scenarios (e.g., behavioral barriers, direct removal) was estimated with a spatially explicit population model, and 3) tradeoffs among identified objectives were evaluated to identify actions to implement and uncertainties that would hinder the decision. Recent information from collaborators enabled us to 1) revisit objectives, 2) re-evaluate grass carp abundance estimates across control scenarios, particularly new barrier effectiveness levels, and 3) identify sources of uncertainty that are relevant in the AM decision context. Response scenarios with direct removal and behavioral spawning barriers had the greatest chance of reaching the management targets, but were the costliest. If resolved, uncertainties in behavioral spawning barrier efficiency, survival, and the underlying stock-recruitment relationship could change the preferred decision among alternative strategies. This work highlights the utility of AM for invasive species- where learning can improve decision-making concurrently with response efforts.

**Karl Bosse**[1], Michael J. Sayers[1], Robert A. Shuchman[1], Steve Ruberg[2], Andrea Vander Woude[2] and Russ Miller[3], [1]Michigan Tech Research Institute, Ann Arbor, MI, USA, [2]NOAA GLERL, Ann Arbor, MI, USA, [3]Cooperative Institute for Great Lakes Research, Ann Arbor, MI, USA. **Building a multi-decadal Great Lakes optical property dataset to track change and improve remote sensing.**

Due to their vast size, it is difficult to adequately monitor water quality in the Great Lakes using traditional *in situ* methods. Remote sensing has thus become a common tool to monitor lake health. However, *in situ* data is still needed to provide feedback regarding the ongoing quality of the remote sensing data. In 2015, MTRI joined a now 20+ year, multi-organizational effort to monitor optical properties in the Great Lakes. This includes inherent and apparent optical properties (IOPs and AOPs), such as beam attenuation, backscattering, surface reflectance and light attenuation coefficients. These properties can provide valuable information about the types and abundance of algal and non-algal particles in the water and water clarity, and IOPs are necessary for calibrating certain remote sensing algorithms. The primary focus of MTRI's effort has been to capture the seasonal and spatial variability of IOPs and AOPs within the highly dynamic western basin of Lake Erie and Saginaw Bay, while also capturing select measurements in the rest of the lakes. Starting in 2023, MTRI will begin collecting measurements of all five lakes aboard the Lake Guardian's twice-annual cruises. This will provide routine measurements of the offshore waters and greatly expand our limited set of spring-time measurements, allowing us to better track change over time and investigate the spatial variability of our metrics. This data will also be crucial for helping to validate the soon-to-be-launched hyperspectral NASA PACE satellite and calibrate future hyperspectral algorithms.

**Britney Bourdages**[1] and Emilie DeRochie[2], [1]Mohawk Council of Akwesasne, Akwesasne, ON, Canada, [2]Great River Rapport, River Institute, Cornwall, ON, Canada. **Successes, Challenges, and Lessons learned: Collective Impact for a beautiful & Healthy St Lawrence River.**

The Upper St. Lawrence River (USLR) watershed, home to over half a million people, spans Quebec, Ontario, New York, and the Mohawk Territory of Akwesasne. Communities and ecosystems in the region have been severely impacted by large-scale developments that have contributed to contamination and habitat destruction. Meanwhile, jurisdictional divides and the marginalization of Indigenous knowledge systems and place-based ways of knowing have posed barriers to coordinated data collection and data sharing, as well as effective and inclusive science communication and knowledge mobilization. A number of networks have formed to address these barriers and connect community groups with government, academic, and non-profit scientists and practitioners, but have tended to operate at relatively local scales. More recently, coordinated efforts have aimed to create a more formalized platform for inclusive and equitable science, communication, and coordinated management across the USLR. The formative phase of the initiative, titled the "River Strategy", is currently co-led by the Mohawk Council of Akwesasne – Environment Program and the St. Lawrence River Institute. Following a Two Row Wampum approach, it aims to build relationships for cooperation that are grounded in peace, friendship, and a mutual respect for cultural and political autonomy. This presentation will highlight this project, its successes, challenges, and lessons learned to offer insights for other regions, and contribute to discussions about equity and justice in environmental science practice.

**Patrick V Boynton**, James M Watkins, Taylor Nicole Herne and Lars G. Rudstam, Cornell Biological Field Station, Bridgeport, NY, USA. **Does Age Matter? Daily Migration Patterns of *Mysis diluviana* in the Laurentian Great Lakes.**

*Mysis diluviana* is a macroinvertebrate native to the Laurentian Great Lakes that provides a link between benthic and pelagic habitats due to its unique life history strategy. It is well understood that mysid populations exhibit a daily diel vertical migration; however, a proportion of the population has been observed foregoing this migration to remain on the bottom. Additionally, mysids have been observed suspended deep within the water column during the day at sites deeper than 100m. Our goal is to examine mysid populations in the Great Lakes using vertical net tows of varying depths to determine where in the

water column mysids are residing. This is achieved using a comparison of long term monitoring zooplankton and mysid samples, as well as non-traditional whole water column zooplankton net tows and daytime mysid samples. By combining these sampling techniques we gain insight into whether mysids are exhibiting habitat partitioning between age classes at deep sites, both during the day at the bottom as well as during the night with some mysids migrating into the water column and some remaining on the bottom. If so, mysid biomass may be under represented and relationships between mysids and other organisms may be less clear than previously understood.

**Evie Brahmstedt**[1] and Roxanne Razavi[2], [1]New York State Water Resources Institute, Cornell University, Ithaca, NY, USA, [2]Department of Environmental Biology, SUNY ESF, Syracuse, NY, USA. **Where have we been and where are we going: contaminants in the Great Lakes.**

Contaminants are primary concern for stakeholders and rightsholders across the Great Lakes Basin. The Great Lakes Water Quality Agreement (GLWQA) mandates the collaborative research, management, and political action necessary to limit contaminants in Great Lakes natural resources. As an international society on Great Lakes research, IAGLR affiliates have a responsibility to fulfill the GLWQA and to the constituents impacted by the treaty. Climate change has begun to impact contaminants and the systems that interact with contaminants. To progress Great Lakes contaminants research into the future in the face of climate change, we need to understand where our efforts have been and where they are at the present to A) bring forward past lessons, and B) identify knowledge gaps in our current efforts. We have used historic IAGLR conference programs to extract data on talks, posters, and sessions from 2009-2021 related to contaminants, under the assumption that IAGLR conference data is a proxy for basin-wide contaminants research efforts. Preliminary data indicated in recent years (2018-2021) contaminants talks made up, on average, 12.8% of all IAGLR conference talks, and only 17.8% of those talks were on legacy or emerging contaminants. Rather, harmful algal blooms and microplastics/plastics talks make up the majority, 54.5% (32.6% and 21.9%, respectively). As a Great Lakes community, we must decide if our efforts align with our priorities, and if not, consider changes that better address priorities moving forward under climate change.

Michael Joseph Donahue[1], **John F. Bratton**[2], Tad Slawecki[2], Matthew Child[3], Lizhu Wang[3], Michael Twiss[4] and Lucinda B. Johnson[5], [1]AECOM Technical Services, Inc., Traverse City, MI, USA, [2]LimnoTech, Ann Arbor, MI, USA, [3]International Joint Commission, Windsor, ON, Canada, [4]Faculty of Science, Algoma University, Sault Ste Marie, ON, Canada, [5]NRRI, University of Minnesota Duluth, Duluth, MN, USA. **Operationalizing a Great Lakes Early Warning System.**

The Science Advisory Board (SAB) of the International Joint Commission (IJC) is refining a Great Lakes Early Warning System (GLEWS) framework that allows the scientific and management communities to "get ahead of the curve" in addressing an array of emerging/anticipated issues before they threaten the ecological integrity of the Basin. An initial effort generated structural and operational characteristics of GLEWS and is now being refined through the review of other early warning systems; further development of a decision-making protocol; an in-depth analysis of five case studies; and conduct of an experts' workshop. Knowledge gained is facilitating the next critical step; refining the GLEWS framework by identifying, categorizing and prioritizing the likelihood/severity of potential stressors and threats on the basis of their probability of occurrence and potential impact. Operationalizing GLEWS offers tremendous ecological and economic benefits by placing an emphasis on the identification and prevention of issues that might otherwise pose significant and perhaps intractable ecological problems. This presentation will demonstrate the broad applicability of GLEWS by highlighting the outcomes of the literature review, case study analyses and experts' workshop, as well as resultant refinements to GLEWS structure and operation.

**Thomas Bridgeman**[1], Kuo-Pei Tsai[1], Christian Moldaenke[2], Zachary Kirschman[3] and Youngwoo Seo[3], [1]Lake Erie Center, University of Toledo, Toledo, OH, USA, [2]bbe-Moldaenke, Kiel, Germany, [3]Department

of Civil and Environmental Engineering, University of Toledo, Toledo, OH, USA. **When HABs go bad: Detecting cell rupture and toxin release.**

Elevated levels of extracellular cyanotoxins in lakes due to rapid cell lysis of harmful cyanobacterial blooms may pose serious challenges for drinking water treatment and an increased risk of human exposure through dermal contact and aerosolization of toxins. Catastrophic cell lysis can result from outbreaks of naturally- occurring cyanophages – as documented in Lake Erie during the Toledo Water Crisis of 2014 and in 2019, or through the over-application of water treatment chemicals. Real-time detection of cyanobacteria-specific cell lysis may provide a valuable tool for drinking water plant managers and could inform recreational users. We used a recently-developed online fluorometer, PhycoSens, that is able to detect a new parameter, unbound phycocyanin, as a potential real-time indication of cell lysis and toxin release. In a field study, the Lake Erie intake water at the Toledo water plant was analyzed every 15 minutes from July 15-Oct 17, 2022. Appearance of unbound phycocyanin showed evidence of cell lysis on Sep. 30th during bloom senescence. In the laboratory study, microcystin toxin-producing *Microcystis aeruginosa* NIES-298 at initial cell density of 105 cells/mL (approximately 120 µg chlorophyll/L) was exposed to cyanophages for 96 hours, and the cyanobacterial suspension was monitored every 60 minutes. A surge of unbound phycocyanin along with a decline of cyanobacterial biomass was observed within 48 hours, corresponding to an increase in the ratio of extracellular to intracellular microcystins.

**Linden Brinks**[1], Tim Kearns[1] and Tylar Murray[2], [1]Great Lakes Observing System, Ann Arbor, MI, USA, [2]USF, St. Petersburg, FL, USA. **Lakebed 2030: Visualizing Progress.**

The Great Lakes Observing System has been working with multiple stakeholders around the region to better understand the inventory of high and low density data holdings on both sides of the border. Parallel to this effort, GLOS has been developing a data pipeline to handle volunteer submitted bathymetry data, data from multiple jurisdictions or agencies and more. The ultimate goal is a high resolution, comprehensive surface of the Great Lakes lakefloor. Visualizing what we have, and where there are gaps in the data is a mapping challenge. Through the use of open source hexagon tessellations, we are able to visualize data density across the entire region at multiple scales. Knowing what we have and more importantly where the gaps are, will help drive new and encompassing mapping missions to realize the goal of Lakebed 2030.

**Soren Brothers**[1], Melissa Cobo[2], Tobias Goldhammer[3] and Erin Brothers[2], [1]Climate Change, Royal Ontario Museum, Toronto, ON, Canada, [2]Utah State University, Logan, UT, USA, [3]IGB Institute, Berlin, Germany. **High $CO_2$ fluxes from the desiccated areas of a saline lake are unaccounted anthropogenic emissions.**

Multi-seasonal intensive and synoptic sampling campaigns across the desiccated areas of Great Salt Lake (Utah, USA) revealed elevated carbon dioxide ($CO_2$) emissions from exposed lake sediments to the atmosphere. Available water chemistry, aquatic metabolism, and lake surface flux data further indicate that the aquatic environment of Great Salt Lake is a net sink for atmospheric $CO_2$, making these new "dry-flux" $CO_2$ emissions, a net addition to the atmosphere relative to pre-desiccated conditions. Great Salt Lake surface levels have been on a downward trajectory due to local consumptive water practices, particularly relating to high-intensity agricultural uses within the watershed of this terminal lake. The $CO_2$ emissions thus resulting from lake desiccation are therefore anthropogenic in nature, though returning the Great Salt Lake to its historical lake levels has yet to be publicly discussed as a local climate mitigation and adaptation solution. Accounting for greenhouse gas emissions from anthropogenically desiccated lake beds has far-reaching implications for water management practices around the world, particularly in saline lake basins.

**Bridget Brown**[1] and **Rebecca Nicodemus**[2], [1]Great Lakes and St. Lawrence Cities Initiative, Milwaukee, WI, USA, [2]National Oceanic and Atmospheric Administration (NOAA) Office for Coastal Management

(OCM), Chicago, IL, USA. **Supporting locally-prioritized nature-based solutions to build Great Lakes coastal resilience.**

The Great Lakes shorelines have seen increased damages in recent years from flooding and erosion due to historically high lake levels and severe storm events. Climate change will likely exacerbate these issues. Cities are on the front-lines and research has demonstrated they often lack capacity to deal with these challenges on their own. This presentation will provide an overview of two programs that provide direct technical support to municipalities in the Great Lakes region. The two programs are the Lake Michigan Coastal Resilience Initiative, sponsored by NOAA and the Great Lakes and St. Lawrence Cities Initiative, and funded by EPA through the Great Lakes Restoration Initiative and the Great Lakes and St. Lawrence Cities Initiative's Resilient Coastal Projects Initiative. Both programs seek to build local capacity for incorporating nature-based approaches to addressing coastal hazards and enhancing natural habitats and species through engagement with a cohort of communities in a sub-region or lake basin. This talk will include a discussion of the program models, the municipal engagement approach and case stories with a discussion around some of the challenges and opportunities identified thus far as this work continues.

**Cameron Brown**[1], Robert Hanner[1] and Margaret F. Docker[2], [1]University of Guelph, Guelph, ON, Canada, [2]University of Manitoba, Winnipeg, MB, Canada. **Effectiveness of environmental DNA for routine larval monitoring of invasive Sea Lamprey.**

The Sea Lamprey was one of the first and most destructive invasive species in the Great Lakes, contributing to the collapse of its multibillion-dollar fishery in the 1950s. Ongoing Sea Lamprey control is needed and relies on assessing the presence, distribution, and abundance of larval Sea Lamprey to prioritize streams for treatment. Electrofishing is currently used for larval assessment, but an optimized environmental DNA (eDNA) monitoring program could cost-effectively increase the spatial and temporal extent of assessment. With the US Fish & Wildlife Service and Fisheries and Oceans Canada, we conducted paired eDNA and electrofishing surveys on 12 tributaries where larval Sea Lamprey were present at various densities. We sampled each river at 3-5 stations in summer, fall, and winter, and analyzed the samples using a duplexed TaqMan assay that included a species-specific assay targeting a 154-bp fragment of cytb and an Internal Positive Control (IPC) which tested for PCR inhibition that could cause false negatives. eDNA failed to detect Sea Lamprey at 4/54 stations in each of the summer and fall sampling periods, but the IPC detected inhibition in most of these samples; treatment to relieve inhibition in these cases could improve detectability. Furthermore, with repeated eDNA sampling, the proportion of false negatives decreased. Moreover, eDNA produced novel detections in two rivers where Sea Lamprey were not detected by electrofishing, suggesting greater sensitivity in some situations. eDNA is a promising complement to electrofishing for larval assessment.

**Meredith Brown**, Canadian Geographic, Ottawa, ON, Canada. **Biinaagami, our shared responsibility to protecting the Great Lakes.**

The Great Lakes-St. Lawrence watershed is the world's largest freshwater ecosystem that sustains countless species and influences culture. Canada and the United States have collaborated for over a century to "manage" these shared waters, yet little-known to most people, there are over 200 First Nations living within the watershed with a rich history of acknowledging and celebrating reciprocal relationships with the living world, including lakes, rivers and all water. Biinaagami is a multi-media, change-provoking project, rooted in Indigenous learning, intended to engage and activate national and international audiences in understanding the history and future of the Great Lakes ecosystems. Through mapping, inclusive storytelling, augmented reality and experiential learning we aim to restore just and healthy relations between wildlife, people, and place. Biinaagami is a name in Anishinaabemowin that was gifted to the project by Anishinaabek grandmothers on Manidoowaaling (Manitoulin) Island. It means clean waters and reminds us that water has a spirit, that water must be honoured and respected. The grandmothers emphasize the importance of acknowledging our shared responsibility and encourage a two-eyed seeing approach to

protecting and restoring waters of the Great Lakes-St. Lawrence. Please join us in our mission to create a future that respects and acknowledges Indigenous Rights, embraces Indigenous knowledge and protocols and takes a true multi-nation approach to making decisions related to the waters in the Great Lakes-St. Lawrence watershed.

**Taylor A. Brown**[1], Lars G. Rudstam[2], Suresh A. Sethi[1], David B. Bunnell[3], Ralph W. Tingley III[3], Brian C. Weidel[4] and Andrew E. Honsey[5], [1]Cornell University, Ithaca, NY, USA, [2]Cornell Biological Field Station, Bridgeport, NY, USA, [3]USGS Great Lakes Science Center, Ann Arbor, MI, USA, [4]USGS Great Lakes Science Center, Oswego, NY, USA, [5]USGS Great Lakes Science Center, Millersburg, MI, USA. **Identifying and ranking important drivers of lake whitefish and cisco recruitment.**

Disentangling the complex suite of ecological drivers that explain recruitment variability for lake whitefish (*Coregonus clupeaformis*) and cisco (*C. artedi*) is a critical knowledge gap for the conservation and management of these species in the Laurentian Great Lakes. However, recruitment is inherently variable and can be regulated by myriad interacting factors, the relative importance of which can vary spatially, temporally, and ontogenetically. We held a workshop in February 2023 to synthesize expert opinion on which biophysical processes are driving contemporary coregonine recruitment dynamics and in which contexts (e.g., by species, lake, or life-stage). Workshop participants included fishery professionals with expertise in Great Lakes coregonines and represented multinational government agencies, universities, and non-governmental organizations. Participants were asked to rank the importance of hypothesized recruitment drivers for cisco and lake whitefish, respectively, in each of the Great Lakes and propose specific mechanisms by which those processes regulate recruitment. Outcomes from this workshop are guiding future research on cisco and lake whitefish in the Great Lakes, such as analyzing the spatiotemporal patterns and drivers of year-class strength and developing a conceptual model of recruitment dynamics.

**Shelby Brunner**, Joeseph Smith, Sneha Bhadbhade, Ana Sirviente and Tim Kearns, Great Lakes Observing System, Ann Arbor, MI, USA. **Smarter Lakes: Advances from technology to information delivery.**

Smarter lakes require advances in technology, data services, and information delivery to become truly smarter. The Great Lakes Observing System (GLOS), a regional coastal observing system under the US Integrated Ocean Observing System (IOOS), works towards the Smart Great Lakes Initiative to provide more and better information to end users across the Great Lakes basin. This presentation will highlight some of the collaborative work that GLOS is involved in to support the deployment and use of new observing technologies in the Great Lakes. This involves 1) the development and testing of low-cost platforms capable of transmitting data via satellite, cellular, and/or Low Range Wide Area (LoRaWAN) communication protocols, 2) the use of autonomous vehicles, 3) the work to increase year-round deployments of in-lake observing platforms, as well as 4) the testing of new technologies capable of detecting and identifying harmful algae blooms. In parallel, GLOS also works to support the ingestion, processing, storage, and visualization of the data collected by these platforms, and to make it publicly available via GLOS IT platform, Seagull. Most recent Seagull developments for the visualization of data will also be highlighted.

**Mary-Claire Buell**[1], Barbara L Wall[2] and Chris Furgal[3], [1]Collective Environmental / Trent University, Peterborough, ON, Canada, [2]Trent University, Keene, ON, Canada, [3]Trent University, Peterborough, ON, Canada. **Capturing the landscape of Indigenous-led initiatives and priorities for research in the Great Lakes.**

As the Great Lakes region continues to face numerous management challenges, initiatives such as the Smart Great Lakes Strategic Plan (SGLI), strive to plan for and meet these challenges. Like many initiatives, it was identified that the SGLI is lacking contributions from clear and strong Indigenous voices and perspectives. Our project aims to support the creation of equitable space for Indigenous communities,

Knowledge Holders and practitioners' involvement and contribution to an enhanced collective understanding of the Great Lakes. Phase 1 of our project focused on identifying the current research and monitoring happening in Indigenous communities associated with the lakes; what interests and priorities Indigenous organizations and Nations have, and what their interest may be to engage in some form of a collective effort such as the SGLI. Through literature searches, surveys and consultation with representatives of Indigenous communities, and organizations around the Great Lakes we identified research and monitoring goals, interests and information needs. Phase 1 demonstrated that western science methodology for information gathering falls short of capturing the true landscape of Indigenous led initiatives/ priorities. Phase 2 created opportunity for relationship building between Great Lakes-based Indigenous communities and organizations and created a discussion platform focused on research, and data governance challenges. Outcomes will inform discussions around interests in a collective Indigenous-directed parallel initiative to the SGLI.

**Cal Buelo**[1], Tracie Greenberg[2], Greg Koltun[3], Santina Wortman[1] and Daryl McGoldrick[2], [1]Environmental Protection Agency, Chicago, IL, USA, [2]Environment and Climate Change Canada, Burlington, ON, Canada, [3]U.S. Geological Survey, Ohio-Kentucky-Indiana Water Science Center, Columbus, OH, USA. **Updating binational phosphorus loading estimates for Lake Erie.**

Lake Erie experiences cyanobacteria blooms and associated water quality issues stemming from excess nutrient loading, particularly phosphorus. In 2012, the United States and Canada signed the updated Great Lakes Water Quality Agreement which included commitments to assess progress toward achievement of loading targets, which were revised in 2016. While loads from both countries are calculated annually, the last published compilation of load estimates included data up to 2013. In this presentation we examine a more recent compilation up to 2021 broken down by country, watershed, year, and source. Over the past 8 years, total phosphorus loads from most watersheds have not significantly changed (31 out of 33 no significant trend, 2 increasing, 0 decreasing). Non-point sources continue to contribute the bulk of the phosphorus load (average of 76%), especially during years with high runoff. We also evaluate the impact of load calculation method on annual load accuracy when nutrient concentration data are limited, such as during the COVID-19 pandemic, finding that discharge-based regression methods incorporating previous years of data usually perform better than Stratified Beale Ratio estimates.

**Lu Buller**[1], Timothy Moore[2], Michael J. Sayers[1], Karl Bosse[1] and Robert A. Shuchman[1], [1]Michigan Tech Research Institute, Ann Arbor, MI, USA, [2]Florida Atlantic University, Ft. Pierce, FL, USA. **An optical water type classification scheme for hyperspectral imagery over inland waters.**

Different chlorophyll-*a* algorithms perform best under different biological and optical conditions. Moore et. al. 2014 developed an optical water type (OWT) framework to select and blend chlorophyll-*a* retrievals from different algorithms to generate a hybrid chlorophyll-*a* product with a more uniform and lower uncertainty. With the NASA PACE mission scheduled for launch in 2024, the increased information provided by its hyperspectral sensor is expected to enable higher performance of chlorophyll-*a* algorithms and more sensitive detection of HABs. MTRI researchers have adapted the method used by Moore et. al. 2014 to take advantage of this detailed spectral shape information and developed an OWT classification system based on *in situ* hyperspectral remote sensing reflectance measurements (resampled to simulate the spectral resolution anticipated from the PACE mission) from 2015-2019 in the western basin of Lake Erie, which covers a wide range of water quality conditions including HABs. Results show significant differences in several water quality variables between the different OWTs. The applicability of the hyperspectral OWT classification system to imagery was demonstrated using HICO images of Lake Erie from 2013-2014.

**David B. Bunnell**[1], Patricia M Dieter[2], Paris D Collingsworth[3], Joel C Hoffman[4], Ryan Lepak[4], Edward Rutherford[5] and Maddie Tomczak[6], [1]USGS Great Lakes Science Center, Ann Arbor, MI, USA, [2]U.S.

Geological Survey, Great Lakes Science Center, Ann Arbor, MI, USA, [3]Illinois-Indiana Sea Grant, West Lafayette, IN, USA, [4]USEPA ORD Great Lakes Ecology and Toxicology Division, Duluth, MN, USA, [5]NOAA GLERL, Ann Arbor, MI, USA, [6]University of Michigan CIGLR, Ann Arbor, MI, USA. **Larval coregonine dynamics in Lake Michigan and Huron, 2015-2021.**

Since 2014, efforts to sample coregonines (Lake Whitefish, Cisco) in the shallow nearshore (< 10 m) habitats of Lakes Michigan and Huron have been increasing, while efforts to sample larval fishes in more offshore waters have not been consistently undertaken. Recent priorities identified in the Cooperative and Science Monitoring Initiative have facilitated the ability of multiple agencies to sample waters ranging in bottom depth from 15 m to greater than 100 m. In this talk, we describe the spatial and temporal distribution of larval fishes from 2015 (Michigan), 2017 (Huron) and 2021 (Michigan), with a focus on coregonines that are of increasing conservation and restoration interest across the Great Lakes. In 2015 and 2021, sampling emphasized broad spatial coverage in July, but Bloater were the only coregonine sampled and densities in 2021 were three times higher than in 2015. We also documented the largest Bloater larvae to be at the surface, with mean size decreasing when sampling at deeper vertical layers. In 2017, we achieved greater temporal coverage (late-April through August), but Bloater still dominated (97%) the coregonine catch, with only 7 Ciscoes identified through genetics. These efforts enhanced our understanding of how best to monitor larval coregonines, which ultimately will improve the ability to monitor the effectiveness of restoration actions.

**Katherine Bunting-Howarth**[1] and **Andrea Harder**[2], [1]Cornell University - New York Sea Grant, Ithaca, NY, USA, [2]University at Buffalo, Buffalo, NY, USA. **Climate-Induced Human Migration in the Great Lakes Basin.**

Climate change impacts will continue to impact the habitability of coastal communities. By the end of the century, 13+ million U.S. residents could be displaced as a result of sea level rise. The Great Lakes region is often described as a future climate destination due to its northeastern and midwestern location, an abundance of freshwater resources, and room to accommodate growth. Despite increased reference to the link between climate change and human mobility (which includes displacement, migration, and planned relocation), there is a lack of knowledge regarding how climate-induced population shifts will impact socio-economic and ecological processes in both sending and receiving communities, what will be required to adapt to those impacts, and how we can ensure the resilience of our communities. PEople on the MOve in a Changing Climate, an National Science Foundation funded research coordination network, highlights the current state of knowledge on climate-induced human migration, provides the scientific infrastructure that is required to conduct place-based research, and develops context-specific strategies and solutions in collaboration with coastal stakeholders. The associated Great Lakes workshop brought together policymakers, researchers, educators, and experts from a variety of backgrounds gathered to discuss the unique climate migration-related opportunities and challenges that are anticipated in the region. This presentation will discuss outcomes of the regional meeting emphasizing research, outreach and policy needs.

**Lyubov Burlakova** and Alexander Y. Karatayev, SUNY Buffalo State, Buffalo, NY, USA. **Rapid assessment of *Dreissena* populations in Great Lakes.**

Since the late 1990s exotic dreissenids are fundamentally changing the flow of energy and nutrients in Great Lakes ecosystems. To quantify their ecological role, timely and reliable density estimates are extremely important, however samples obtained using conventional methods (bottom grabs or diver assessments) require a long processing time. In 2019-2022 we applied a novel method using a Benthic Imaging System (BIS, a drop down frame equipped with GoPro cameras) across lakes Erie, Michigan, and Huron to estimate dreissenid populations (presence/absence, and density) in near real-time (by the end of the summer cruise), and compared video estimations with data from Ponar grabs. While both methods have their own unique strengths, the BIS-Ponar combined approach demonstrated efficient monitoring advantages that yield valuable information not obtainable by either method alone. BIS may be the only

possible tool to study dreissenid coverage over large areas characterized by hard substrates where bottom grabs are not efficient, and the use of SCUBA is prohibitively expensive. Thus, in 2022 we found a sizable population of dreissenids in the North Channel of Lake Huron overlooked during previous Ponar surveys. In addition, BIS videos could be used to estimate presence and density of round gobies, and, possibly, bottom-dwelling Mysis.

**Julie Atieno Bwoga**[1], Philip Raburu[2] and Geraldine Matolla[2], [1]Rhodes University, Makhanda, CapeTown, South Africa, [2]University of Eldoret, Eldoret, Kenya. **Climate change-induced effects of temperature on parasite-fish interactions.**

Climate change directly affects the distribution and host switching of fish parasites. Higher temperatures often increase parasite growth, reproduction and infectivity yet can also escalate parasite mortality. This study highlighted the effects of seasonality on monogenean and digenean trematode parasites in *Oreochromis niloticus* reared in cages in Lake Victoria, Kenya. Parasites isolated were the monogenean *Dactylogyrus* and the digenean; *Tylodelphys, Clinostomum,* and *Neascus.* All the water quality variables other than pH recorded greater values during the dry season. There was a general positive correlation between water temperatures and mean parasite intensity. Temperature significantly differed between the seasons ($p < 0.0001$) with Dissolved Oxygen (DO) significantly higher during the wet season ($p < 0.01$). Total Dissolved Solids (TDS) presented a general negative correlation with mean parasite intensity in all species except in *Clinostomum sp.* which showed a positive trend. Kruskall-Wallis test indicated significant variation in the prevalence of attack between the parasite species both in the wet season ($H = 17.793$; $df = 3$; $p < 0.0001$) and dry season ($H = 30.226$; df 3; $p < 0.0001$). In conclusion, climate change-induced effects such as increased water temperature, and low DO imposed severe risks to fish health leading to an increase in parasite incidence and infectivity. This creates the need to monitor water quality for sustainable aquaculture.
**Keywords:** Climate change, Parasite-Fish Interaction, Distribution, Host-switching, Infectivity.

# C

**Sarah K. Caltabiano**[1], Hyatt Green[1] and Gregory L. Boyer[2], [1]SUNY College of Environmental Science and Forestry, Syracuse, NY, USA, [2]SUNY Environmental Science and Forestry, Syracuse, NY, USA. **Our current understanding of nitrate reductase in *Microcystis*.**

Nitrogen is a crucial nutrient for cyanobacterial growth. Many genus of cyanobacteria can fix atmospheric nitrogen to help meet their nitrogen requirements. However, *Microcystis,* one of the most notorious cyanobacteria found in harmful algae blooms, cannot fix $N_2$. Instead, *Microcystis* must rely on bio-available sources of nitrogen, such as nitrate, for growth. Nitrate reductase is necessary for the assimilation of nitrate in *Microcystis*. However, most of our understanding of nitrate reductase is based on studies conducted using cyanobacteria such as *Anacystis* and *Synechococcus*. For us to fully understand this enzyme in *Microcystis,* and the potential role that it might play in HABS, we examined the ideal conditions to run the enzyme assay, location of the enzyme within the cell, the rate of activity for this enzyme over the growth of batch cultures in lab, gene expression of nitrate reductase related genes, and phylogenetic analysis of nitrate reductase genes found in *Microcystis aeruginosa* PCC7806.

**Sara E. Campbell**[1,2], Justin Hubbard[3] and Nicholas E. Mandrak[4], [1]University of Toronto, Toronto, ON, Canada, [2]University of Tennessee Knoxville, Knoxville, TN, USA, [3]Department of Physical and Environmental Sciences, University of Toronto Scarborough, Scarborough, ON, Canada, [4]Department of Physical and Environmental Sciences, University of Toronto Scarborough, Toronto, ON, Canada. **Invasion risk of introduced fishes in the Laurentian Great Lakes altered by changing climate and community dynamics.**

We developed a comprehensive, integrative risk assessment framework and used it to screen 34 previously failed introduced freshwater fish species in the Laurentian Great Lakes under changing community dynamics and future climate-change scenarios. These species, commonly found in the aquarium trade, likely previously failed due to low propagule pressure, a mismatch in abiotic conditions, and/or biotic resistance. We quantified how the probability of establishment success and the probability of having high ecological impact changed between the decade of first introduction and present-day communities using established trait-based models while incorporating changes in composition of the recipient community. A climate match analysis under future climate-change scenarios was completed based on 16 bioclimatic variables. This predictive framework identified seven species that have an increased climate match and an increased probability of establishment success in at least one lake and several species with a high predicted probability of ecological impact that should be targeted in surveillance and management efforts.

**David Cannon**[1], Jia Wang[2], Ayumi Fujisaki-Manome[1] and James Kessler[2], [1]Cooperative Institute for Great Lakes Research, University of Michigan, Ann Arbor, MI, USA, [2]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, USA. **Investigating multidecadal trends in ice cover and subsurface temperatures in the Laurentian Great Lakes.**

While changing lake surface conditions have received significant research scrutiny, changes in subsurface conditions, including stratification and heat content, remain largely unexplored. In this work, we highlight changes in thermal structure and ice dynamics in the Laurentian Great Lakes as simulated between 1979 and 2021. Lake hydrodynamics and ice cover were modelled using the Finite Volume Community Ocean Model (FVCOM) coupled with CICE, with three-dimensional model output used to estimate seasonal trends in stratification dynamics, ice conditions, and overturning behavior. Analysis revealed significant increases in surface (0.4 – 0.6 °C/decade) and subsurface (0.1 – 0.4 °C/decade) temperatures as well as dramatic losses in ice cover (1 – 8 %/decade) and ice volume (0 – 3 $km^3$/decade) over the last 40 years. Time series of lake-averaged surface temperatures (LST), bottom temperatures (LBT), and annual averaged ice cover (AAIC) were used to estimate low-frequency climate signals, which were highly correlated with the Atlantic Multidecadal Oscillation. Average heating trends fit to residual climate signals (LST: 0.1 °C/decade; LBT: 0.03 °C/decade; AAIC: -1 %/decade) were nearly an order of magnitude lower than those fit to associated low-frequency components (LST: 0.5 °C/decade; LBT: 0.2 °C/decade; AAIC: -2.5 %/decade). These results suggest that observed climate change in the Laurentian Great Lakes may be more strongly linked natural climate variability than to anthropogenic global warming.

**Stuart Carlton**[1], Cody Catherine Dateno[2] and Katie O'Reilly[3], [1]Illinois-Indiana Sea Grant/Coastal & Great Lakes Social Science Lab, Purdue University Department of Forestry & Natural Resources, West Lafayette, IN, USA, [2]Coastal & Great Lakes Social Science Lab / Illinois-Indiana Sea Grant, Purdue University Department of Forestry & Natural Resources, West Lafayette, IN, USA, [3]Illinois-Indiana Sea Grant / Illinois Natural History Survey, Champaign, IL, USA. **Trust ecology and fisheries management: do trust evenness and richness matter?.**

Fisheries management is inherently complicated, as multiple actors with different goals compete for limited resources and are subjected to rules that are often difficult to assess compliance with. Thus, successful fisheries management relies on mutual cooperation among management agencies and the fishing public. Higher levels of trust between fishers and management agencies are associated with higher levels of perceived legitimacy of management regimes, increased support for management actions, and increased compliance with regulations. But what trust? The trust ecology framework posits that trust is multidimensional: different aspects of trust may influence support for management differently and that higher levels of trust richness and evenness may be associated with higher levels of support for management. However, the influence of trust richness and evenness has been little studied. We examine data from a survey of anglers in Illinois and Indiana to explore (1) the extent to which anglers trust fisheries managers in their state, (2) the richness and evenness of trust in management, and (3) whether higher levels

of trust evenness or richness are associated with higher levels of support for management. Our results have important implications for fisheries management and engagement with fishers in the Great Lakes and beyond.

**Jake Carman**[1], Josef D. Ackerman[2] and Yingming Zhao[3], [1]University of Guelph, Guelph, ON, Canada, [2]Department of Integrative Biology, University of Guelph, Guelph, ON, Canada, [3]Aquatic Research and Monitoring Section, Ontario Ministry of Natural Resources and Forestry, Lake Erie Fishery Station, Wheatley, ON, Canada. **Spawning Habitat and Roughness Flows: Impacts on Walleye (*Sander vitreus*) Egg Displacement and Survival Likelihood.**

The early life history of many organisms, including ecologically and economically important fishes, remains uncertain even though this period is critical to their recruitment. In the case of walleye, displacement of eggs from spawning reefs is a potentially significant cause of poor recruitment. Laboratory experiments were undertaken in a wall jet apparatus to examine egg displacement resulting from the interaction between benthic flow and roughness characteristics (height and wavelength) on spawning reefs. We examined the response of water hardened walleye eggs and shear stress (force per unit area along the substrate) required for their displacement under three distinct roughness flow regimes (skimming, wake interference and isolated roughness) generated on roughness plates by varying the spacing and height of roughness elements. Video analysis revealed that eggs underwent traction, saltation, and suspension depending on the roughness characteristics and water speed. Roughness height significantly effected displacement type: traction dominated when eggs were larger than the roughness height while saltation/suspension dominated when eggs were smaller than the roughness height. These results provide direct measurements of the conditions required to displace eggs from spawning reefs, as well as a means to determine the extent of their transport and potential loss to surrounding soft-sediment regions. This information will be valuable to predict egg displacement in models and allow for the effects of future climate change scenarios to be evaluated.

**Donald Carpenter**[1] and Michael E. Fraker[2], [1]Drummond Carpenter, PLLC, Ann Arbor, MI, USA, [2]University of Michigan, Ann Arbor, MI, USA. **Tools and Tactics for Sustainable Small Harbors.**

Administered by state and local governments, there are over 80 public harbors and marinas throughout the State of Michigan. The annual direct and secondary impacts to the Michigan economy from Great Lakes recreation represent billions of dollars. However, these communities struggle with fluctuating water levels, aging infrastructure, climate change, legacy pollutants, economic shifts, and limited community capacity. These challenges have left harbor communities struggling to adjust. In response, Michigan Sea Grant and the State of Michigan have undertaken the development and dissemination of the *Sustainable Small Harbors Tools and Tactics Guidebook (2nd Edition) (2023)*. The Guidebook includes strategies related to fluctuating water levels, climate change, nature-based solutions for stormwater management, decarbonization, changing economic activity, environmental justice, funding, diverse community participation, and case studies of successful harbor community revitalization efforts. In summary, the Guidebook serves as a toolkit of best practices, resources, and funding opportunities to support small harbor planning efforts as they seek to revitalize and advance resiliency.

**Lyndsay Cartwright**[1], Luke Moslenko[2], Andrew Chin[1], Krista M. Chomicki[1], Tim Van Seters[1], Garrett Des Vignes[3], Chad Harvey[3], Jonathan Ruppert[1], Nikola Erich[2], Suad Sidow[2], Russell Bastow[2], Sophie Antonyshyn[2], Alexander Ivanov[2], Joao Pedro Campos[2] and Claire Oswald[2], [1]Toronto and Region Conservation Authority, Vaughan, ON, Canada, [2]Toronto Metropolitan University, Toronto, ON, Canada, [3]McMaster University, Hamilton, ON, Canada. **Local factors and sources affecting stream chloride concentrations in the Toronto region.**

Increasing chloride concentrations in freshwater streams in the Toronto region and throughout many areas of North America have led to concerns over freshwater salinization of both surface water and groundwater. We identified trends in chloride concentrations at 47 stream monitoring stations between 2000 and 2021 within the Toronto region and identified factors contributing to trends. Chloride concentrations increased significantly at 36 of 47 stream monitoring stations with 24 stations showing increasing trends during the winter (salting) season and 30 stations showing increasing trends during the summer (non-salting) season. Chloride-to-bromide ratios indicated that road salt and/or septic effluent was the dominant source of chloride; however, basin brines and/or animal waste, precipitation, or pristine aquifers also contributed chloride. Inputs varied by season with road salt and/or septic effluent having a higher proportion of inputs during winter compared to summer where a higher proportion of inputs were from basin brines and/or animal waste, landfill leachate, and pristine aquifer. Land use within catchments was related to chloride concentrations with trends in road density positively related to trends in chloride. These results suggest that while land use factors are a significant predictor of trends in stream chloride, several other factors are likely contributing to increasing stream chloride concentrations.

**Megan A. Casler**, Thomas M. Gehring, Benjamin W. Heumann and Donald G. Uzarski, Central Michigan University, Mount Pleasant, MI, USA. **Exploring multi-season occupancy of Rallidae species in Great Lakes coastal wetlands.**

The Great Lakes Coastal Wetlands Monitoring Program is in the 13th year of surveilling the status of water quality and biotic communities of wetlands influenced by the water levels of the Great Lakes. Wetlands are critical habitat, and long term monitoring programs provide critical baseline data on the status of these ecosystems. Long-term data are especially useful in studying secretive marsh birds, such as members of the Rallidae family, with naturally low detection rates. I will be presenting preliminary results of my exploration of regionality, landcover, invertebrate communities, and vegetation cover as they relate to the occupancy of American coots (*Fulica americana*), common gallinules (*Gallinula galeata*), soras (*Sora porzana*), and Virginia rails (*Rallus limicola*) in coastal wetlands across the Great Lakes basin for the current 12 years of monitoring survey data using a multi-season approach. Final results of this analysis will comment on detection of Rallidae species, region specific and species specific habitat requirements, identify crucial wetland habitat areas, inform future wetland preservation and management, and guide Rallidae management in Great lakes coastal wetlands.

**Subba Rao Chaganti**[1], Lucas Vanderbilt[2], Ashley Elgin[3] and Rachel Orzechowski[3], [1]Cooperative Institute for Great Lakes Research, University of Michigan, Ann Arbor, MI, USA, [2]University of Michigan, ANN ARBOR, MI, USA, [3]National Oceanic and Atmospheric Administration, Muskegon, MI, USA.
**Environmental DNA and RNA for detection and abundance measurement of invasive species.**

In recent years environmental DNA has gained an enormous interest among scientific community for its major application as a non-invasive method of detection for variety of species in aquatic and terrestrial environments. Further, it could be used for early detection of invasive species or detection of rare species as it is highly sensitive. However, it has some major challenges such as carryover of legacy DNA could lead to misrepresent of species presence. Another challenge is estimating species abundance. Environmental RNA (eRNA) could be used instead of eDNA, as eRNA degrades much faster than the eDNA. Here we developed a combined multi marker eDNA/eRNA assays that could potential avoid the legacy eDNA issues using Dreissenid mussels as the model organism. eDNA and eRNA samples were collected in parallel to regular mussel collection methods (ponar grab and scuba diving) from multiple locations in Saginaw bay, Lake Huron in 2022. We have compared the multi-marker eDNA/eRNA qPCR methods with mussels collected through ponar grab and scuba diving methods. Our results indicate the novel eDNA/eRNA method not only avoid the legacy DNA issues, but also helps in estimating the relative mussel abundances and also compliments the traditional methods.

**Xuexiu Chang**[1,2], Wenwen Cai[3], Yuanyan Zi[4], Chunxiao Sun[3] and Hugh J. MacIsaac[2,3], [1]College of Agriculture and Life Sciences, Kunming University, Kunming, China, [2]University of Windsor, Windsor, ON, Canada, [3]Yunnan University, Kunming, China, [4]Kunming University, Kunming, China. **Neurotoxicity of *Microcystis* exudates based on fish embryonic, human cellular and computational toxicology.**

Cyanobacterial harmful algal blooms (cHABs), commonly dominated with *Microcystis aeruginosa,* threaten aquatic health by releasing toxic compounds. Neurotoxicity is one of the most concerning hazards of cHABs. In addition to the well-known neurotoxins such as anatoxin-a and saxitoxin, *M. aeruginosa* also release exudates (MaE) of complex chemical mixtures that cause neuro-impairment. Using a systematic toxicology test, including fish embryonic/ larval, human cellular and computational models, we tested the hypothesis that MaE mixtures damage the nervous health in animals. We found that MaE inhibited fish neurobehavior (such as touch response and swimming distance) which resulted from excitatory neurotransmitters (acetylcholine and dopamine) decreases. MaE also decreased the viability and proliferation of a human astrocyte cell line via damage to DNA and cytoskeleton. 46 of 72 neurotoxicity targets from the EPA's Toxicity Forecaster (ToxCast) database were affected by this MaE mixture. Neurotoxicity could be initiated via blocking calcium voltage-gated channel, antagonizing neurotransmitter receptors, or inhibiting solute carrier transporters, to impaire neurotransmission. We identified 9 neurotoxic MaE compounds with high affinity to those targets, including LysoPC(16:0), 2-acetyl-1-alkyl-sn-glycero-3-phosphocholine, egonol glucoside, and phytosphingosine. Our study enhances understanding of cHAB exudates' neurotoxicity, which may contribute to future water management.

**Emiy Jepyegon Chemoiwa**, University of Eldoret, Eldoret, Kenya. **A Study *o*n Diversity of *Labeobarbus altianalis* Populations in Lake Victoria Watershed Using MtDNA.**

*Labeobarbus altianalis* populations have declined in Lake Victoria probably due to anthropogenic activities and hence there is need to identify remaining populations for purposes of conservation and management. In this study, genetic characterization of the endangered cyprinid a species known to be potamodramous in four main rivers draining Lake Victoria was carried out on samples from rivers Nzoia, Nyando, Yala and Sondu-Miriu. To assess genetic diversity, population structure and phylogeny of this species, the mitochondrial control region and CO1 were used. The 196 samples yielded 49 mitochondrial DNA haplotypes and 83.7% of these haplotypes were private haplotypes restricted to particular rivers. The overall mean haplotype diversity was high (0.936±0.008) and ranged between 0.566 (Sondu–Miriu) and 0.944 (Nzoia). The overall mean nucleotide diversity was low (0.013±0.001). The *L. altianalis* populations in the Lake Victoria have thus maintained high genetic diversity despite adverse ecological changes in the catchment. The decline of migratory populations could have created opportunities for population expansion. The existence of genetically robust population of L. altianalis in the L. Victoria catchment rivers should provide new impetus for conservation of these species. The four populations should be regarded as Evolutionary Significant Units (ESUs) and river basin specific management measures instituted to protect these populations.

**Yu-Ting Chen**[1], Scott Mundle[1], Thomas Reid[2] and Chris Grant Weisener[1], [1]Great Lakes Institute for Environmental Research, University of Windsor, Windsor, ON, Canada, [2]Environment and Climate Change Canada, Water Science and Technology Branch, Canada Centre for Inland Waters, Burlington, ON, Canada. **Investigating nutrients sources and retention capacity along a river-lake corridor in a mixed land use watershed.**

Improving the impaired status of water quality resulting from nutrient pollution remains top priority to tackle for water quality management of the Laurentian Great Lakes. In this study, a highly nutrient-polluted watershed of Lake Erie in southwestern Ontario is chosen to investigate nutrient transport, sinks and sources along a river-lake continuum. Using dual nitrate isotope approach with water chemistry data, evidence suggested inorganic nitrate and/or nitrate from nitrification incorporated with rainwater isotopic signatures possibly contribute to surge in concentration of nitrate in the area. Within the watershed, sources

of nitrate were generally subject to mixing of at least two end members- inorganic nitrate fertiliser and organic/manure fertiliser. Further, large spatial variation in concentrations of nutrients and sediment equilibrium phosphorus concentration ($EPC_0$) was observed along the transect. Limited phosphorus retention capacity correlated with nutrient buildup. With additional land use information, our findings suggested a combination influence from urban expansion, agriculture, and possible greenhouse footprints contributing to dissolved nutrients. The outcome of this study, with critical area identified, further provide future direction for devising effective nutrient management plan at watershed scale.

**Aisha S Chiandet**, Severn Sound Environmental Association, Port McNicoll, ON, Canada. **Beyond delisting in Severn Sound – How do things look 20 years after the party is over?.**

Severn Sound is a complex of bays and inlets in south-eastern Georgian Bay and was listed as an AOC in 1985 because of eutrophication and habitat loss. The Severn Sound Remedial Action Plan started out as a federal-provincial initiative and became the second AOC to delist when the community of small urban centers and rural townships took their responsibility seriously and became fully committed to the restoration of Severn Sound as a "toxic hot-spot" on the Great Lakes. The transition from an external federal-provincial program to a local organization, the Severn Sound Environmental Association, supported by a variety of partners led to successful implementation and ultimate delisting of the AOC in 2003. Following delisting, creative local partnership agreements and financing were arranged to continue long-term implementation and to meet emerging environmental challenges such as climate change, invasive species, and land use alteration. This presentation will provide an overview of the state of Severn Sound 20 years post delisting in relation to RAP targets and BUIs, approaches used to evaluate restoration efforts, and explore challenges and opportunities in navigating life after delisting.

**Gladys Chigamba**, Fisheries Department, Government of Malawi, Lilongwe, Malawi. **Costing ecosystem services for rivers, does it matter in management? A case of Linthipe River in Southern Africa.**

Valuation of ecosystem services has an important role to play in managing adverse effects of climate change on the riverine resources. However, literature shows a dearth of information regarding values of ecosystems and factors that influence people's willingness to pay (WTP) for riverine resources. This research study was undertaken to estimate the value of aquatic resources and key factors that affect the willingness of people to pay for managing the adverse effects of climate change in the lower section of the Linthipe River, a major tributary of Lake Malawi. Data was collected through household interviews, focus group discussions, key informant interviews, and contingent valuation (CV) surveys. The study noted that communities were willing to offer annual household contribution of $3.51 per household (generating aggregate annual value of $116,312.38) for managing adverse effects of climate change on riverine resources. The people's WTP is a function of education level, household usage of the goods and services, community support in the management of the resources, household income, and distance of the household from the river ecosystem. The study further discovered that the pay-out level of the users along Linthipe River was driven by household usage of resources from the river, period of stay in the area, and level of household income. The study recommends Government and stakeholders to popularize ecosystem values and appeal for more support towards managing the adverse anthropogenic and climate change effects on the African rivers.

**Matthew Child**[1], Lucinda B. Johnson[2], Michael Twiss[3], Lizhu Wang[4], John F. Bratton[5], Tad Slawecki[5] and Michael Joseph Donahue[6], [1]International Joint Commission, Windsor, ON, Canada, [2]NRRI, University of Minnesota Duluth, Duluth, MN, USA, [3]Faculty of Science, Algoma University, Sault Ste Marie, ON, Canada, [4]GLRO, International Joint Commission, Windsor, ON, Canada, [5]LimnoTech, Ann Arbor, MI, USA, [6]AECOM Technical Services, Inc., Traverse City, MI, USA. **Framing an Early Warning System for the Great Lakes.**

The International Joint Commission (IJC) and its Water Quality Board is assigned a role under the Great Lakes Water Quality Agreement to provide recommendations to the U.S. and Canadian governments regarding "current and emerging issues related to the quality of the Waters of the Great Lakes". In order to assist the IJC with fulfilling this role, the IJC's Science Advisory Board has been leading an effort to identify an organizational and operational framework for a Great Lakes Early Warning System with a focus on detection of both suspected and unknown threats. The presentation will identify the need for an early warning system and the supporting functions that are required including data gathering, analysis and modeling functions, coordination, reporting, and related activities associated with horizon scanning.

**Memory Chimpesa**, Monkey Bay Capture Fisheries Research Centre, lilongwe, Malawi. **Reviewing the socio-economic role of the fisheries sector in developing countries: The case of Malawi.**

Lake Malawi is known to have the highest diversity of fish when compared to all freshwater bodies worldwide. These fisheries resources are a source of food and provide a number of socio-economic benefits and maintain ecosystem processes in the lake. This literature review study has highlighted the importance of fish to the socio-economic status of Malawi. The sector directly employs about 90,000 people in fish farming and fishing and over 500,000 in other ancillary activities. Economically, the sector contributes 4% to the national GDP while nutritionally, fish contributes over 40% of total proteins and 70% of animal proteins. The fisheries sector has witnessed an increase in the per capita fish consumption, reaching 12.63kg/person/year in 2018, from 5.36kg/person/year in 2009. While the fish farming has a noticeable involvement of women, the capture fisheries sub-sector is male dominated with only 1% women involvement. The fisheries sector reports some revenues from monitoring of resources for sustainable utilization and licensing fees for both small-scale and commercial trawl fisheries. The sector just like any other sector was significantly impacted by the Covid-19 pandemic particularly in the foreign exchange transactions. With all the above-mentioned benefits, it is imperative that the fisheries resources should always be properly managed to ensure a prolonged benefit to the ever-increasing population of the economically poor Malawi.

**Andrew Chin**[1], Sharon Lam[2], Aidin Akbari[1], Meaghan Eastwood[3], Namrata Shrestha[2] and Jonathan Ruppert[1], [1]Toronto and Region Conservation Authority, Vaughan, ON, Canada, [2]Toronto and Region Conservation Authority, Toronto, ON, Canada, [3]Region of Waterloo, Kitchener, ON, Canada. **Developing a Nature-based Climate Solutions Siting Tool for the Toronto Region.**

The Nature-Based Climate Solutions (NBCS) tool is multi-value approach that attempts to balance ecological and societal challenges, brought about by climate change, by identifying high value areas that should be prioritized for protection, restoration, and enhancement efforts. Here we developed a geospatial, multicriteria assessment siting tool that could help inform the strategic actions for natural features as well as implementation of green infrastructure (e.g., urban forest). The NBCS siting tool was piloted for the Humber River watershed in the Toronto region to evaluate the efficacy of this approach for purposeful consideration of multiple benefits and potential trade-offs. Altogether a total of 14 indicators of various ecosystem functions and services were included under four broad themes: Carbon, Hazard, Community Health, and Ecosystem. Each indicator was assessed based on criteria for protection, restoration, and enhancement. Through a Multiple Hits Analysis (MHA), we identified priority areas for protection, restoration, and enhancement for each theme as well as the overall priorities by combining all themes. Ultimately, the NBCS siting tool provides a framework that could be scaled up and replicated across Canada to help identify strategic locations where nature-based projects that balance multiple values is desirable. The next phase of research will seek to expand the tool to cover the remaining eight watersheds in the Toronto region and be applicable to other potential users in the Greater Golden Horseshoe and beyond.

**Natalie Chin**[1] and **Karina Heim**[2], [1]Wisconsin Sea Grant, Superior, WI, USA, [2]Lake Superior National Estuarine Research Reserve, Superior, WI, USA. **The Lake Superior Climate Champions Program: Building climate resilience through local action.**

Meaningful climate action at the local community scale can emerge when fostered over time by close collaboration and supportive partnerships. To advance this type of climate adaptation in northern Wisconsin coastal communities, the Lake Superior National Estuarine Research Reserve and Wisconsin Sea Grant have joined together to create a new program, Lake Superior Climate Champions. The goal of this program is to provide local leaders with a full year of technical assistance to meet a climate goal of their choosing. In this inaugural year of the program, the two participating community teams are focused, respectively, on (1) developing coastal climate adaptation plans and (2) improving road maintenance documentation systems to help both pre- and post-extreme weather events. Program facilitators are committed to building a program that focuses on the "why" of climate action and centers relationship-building. This presentation will share updates from the midpoint of the program's first year, including progress on community goals and lessons learned so far, next steps, and advice for others hoping to start a similar program in their communities.

**Krista M. Chomicki**[1], Chris T Parsons[2], David C Depew[3], Sarah Kaykhosravi[4], Mahyar Shafii[5] and Tyler J. Harrow-Lyle[2], [1]Toronto and Region Conservation Authority, Vaughan, ON, Canada, [2]Environment and Climate Change Canada, Burlington, ON, Canada, [3]Environment and Climate Change Canada, Water Science and Technology Branch, Canada Centre for Inland Waters, Burlington, ON, Canada, [4]University of Waterloo, Waterloo, ON, Canada, [5]Ecohydrology Research Group, University of Waterloo, Waterloo, ON, Canada. **Unraveling nearshore temporal patterns: marsh, stormwater, tributary, and point source influences in W. Durham, LO.**

Lakewide eutrophication and shoreline algal fouling were major issues threatening the health of the Lower Laurentian Great Lakes in the 1960s and 1970s. Reductions in land-based nutrient loadings led to water quality improvements; however, there has been a resurgence of algal fouling occurring in the nearshore regions of all of the Lower Great Lakes, including the nearshore region by Western Durham, Lake Ontario. The Western Durham nearshore has a variety of potential nutrient sources including coastal marshes, storm drain outlets, rivers/creeks, and a water pollution control plant. This talk will outline the watershed and nearshore monitoring in Western Durham, highlighting local watershed loading and in-lake temporal phosphorus trends. It will showcase collaborative coastal marsh, stormwater, and algal projects vital to understanding the influences on local nearshore water quality. Long term monitoring programs and collaborations are wise investments and lead to informed decision making and management efforts.

**Keoni Chong**[1], Yingming Zhao[2] and Josef D. Ackerman[3], [1]University of Guelph, Guelph, Canada, [2]Aquatic Research and Monitoring Section, Ontario Ministry of Natural Resources and Forestry, Lake Erie Fishery Station, Wheatley, ON, Canada, [3]Department of Integrative Biology, University of Guelph, Guelph, ON, Canada. **Linking hydrodynamics to foraging: The swimming and feeding of walleye larvae (*Sander vitreus*) in turbulent flows.**

Newly hatched walleye must be able to competently swim to escape predators and hunt prey. Water turbulence has been shown to affect a fishes' ability to swim and feed, by contributing to the relative motion between predator and prey. To better understand the feeding dynamics between fish larvae and their planktonic prey, we investigated the interaction between turbulence and larval feeding. We conducted weekly experiments using walleye larvae in a recirculating flow chamber throughout their entire larval development and assessed their feeding success and critical swimming speeds (*UCrit*; a measure of maximum sustainable swimming speeds) under different flow velocities and turbulent conditions. We found that the total length and gape size when feeding was first observed (25-26 days post hatch) coincided with the largest increase in *UCrit*. *UCrit* increased exponentially over larval development and was linearly related to the total length of the larvae. *UCrit* decreased significantly at higher turbulences and larger eddy length

scales. Our findings suggest that turbulence could affect feeding indirectly through its effects on the swimming behaviour of fish larvae and play a complex role in the early life of walleye.

**Andrea Chreston**, Karen McDonald, Ralph Toninger, Hillary Morris and Gord MacPherson, Toronto and Region Conservation Authority, Vaughan, ON, Canada. **Evolution of an urban wilderness: 27 years of habitat restoration, monitoring and public engagement.**

This presentation sets the stage for 'The Leslie Street Spit - Tommy Thompson Park: exploring the creation of a biodiversity hotspot' session. Initially built for port infrastructure, plans for the Leslie Street Spit shifted in the 1970s to a public park, and following natural succession, a wilderness park (Tommy Thompson). A Master Plan approved in 1995 guides habitat creation and restoration, trails, infrastructure, and programming. Aquatic restoration projects created and improved 40ha of wetland, shoreline, transitional and deep-water habitats for fish and wildlife; terrestrial projects targeted riparian and meadow plantings to enhance 30ha with more than 400,000 stems planted. 18-km of trails have been formalized to manage public use of natural areas, and four buildings provide space for education and interpretation programs to foster public understanding, appreciation, and stewardship of nature and the environment. The park provides essential habitat for wildlife and excellent opportunities for monitoring. Monitoring programs include songbirds (passive capture and observation), breeding birds, fish communities (electrofishing and seine netting), amphibians (marsh monitoring), colonial waterbirds, and emergent aquatic plants. Monitoring results help evaluate the success of restoration work, detect invasive species, and guide future restoration and management. Strategic natural area management focuses on cormorants (promote ground nesting), beavers, and invasive plants (8 species including Dog-strangling Vine and Phragmites).

Karen McDonald, **Andrea Chreston**, Ralph Toninger, John DiRocco, Hillary Morris and Gord MacPherson, Toronto and Region Conservation Authority, Vaughan, ON, Canada. **Creating and managing wetlands on a constructed landform in Toronto.**

Historically, the area at the mouth of the Don River in Toronto was a 500ha coastal marsh. Reportedly the largest coastal wetland on the north shore of Lake Ontario, it provided habitat for hundreds of wildlife species. Pressure for economic development in the early 1900s resulted in the filling of the wetland, leaving today's hard, industrial landscape. The Leslie Street Spit (the Spit), a 5km, 500ha constructed landform now extends into Lake Ontario from the original southern edge of the wetland. Due to 50 years of construction, the configuration of the Spit is varied and includes sandy peninsulas, sheltered embayments, and three confined disposal facilities. When the Spit evolved into a wilderness park in the 1980s, the Master Plan included natural area enhancement and creation projects aimed at replacing a portion of the essential habitat lost on the waterfront. Toronto and Region Conservation Authority created three coastal wetlands (total 23ha) at the Spit. Two confined disposal facilities were capped, graded, contoured, and filled with structural habitat features and native plants. One sheltered embayment was converted to a wetland by building a berm to isolate it from the lake, and adding structural habitat features and native plants. The wetlands are connected to the lake through fish and water level control structures, allowing for Common Carp exclusion and water level management. Although the wetlands support diverse fish and wildlife communities, there is on-going adaptive management to address challenges including *Phragmites australis* and beavers.

**Erin Christian**, Maria Sepúlveda and Paris D Collingsworth, Purdue University, West Lafayette, IN, USA. **Evaluating multiple stressors using Chironomids in Lake Erie.**

Per- and polyfluoroalkyl substances (PFAS) are widespread emerging contaminants that persist in the environment. Aquatic non-biting midges of the genus *Chironomus* are highly sensitive to PFAS, but the mechanisms driving this enhanced sensitivity are unknown. Another important stressor in the Great Lakes is hypoxia which can lead to decreases in species abundance. Chironomids have a high concentration of

hemoglobins (Hbs) which helps them survive under a wide range of oxygen levels. Since PFAS have a very high affinity to proteins, they could be affecting the transport of oxygen by Hbs leading to adverse effects, which could help explain their high sensitivity to PFAS. As a first step in assessing the potential impacts of PFAS and hypoxia to Chironomids, we sampled midges from Lake Erie prior to, during, and post-hypoxia and quantified PFAS (> 60 types) in whole bodies, water and sediment. Changes in the expression of Hb will be used as a sensitive biomarker of exposure to PFAS and hypoxia. Our data will provide vital information into the relationship between Hb gene expression and exposure to PFAS and hypoxia, setting the stage for the use of Chironomids as bioindicators of water quality conditions helping inform Great Lakes management decisions.

**Lisa Cicchetti**[1], Shelley Arnott[2] and Pedro Sartori Manoel[1], [1]Queen's University, Kingston, ON, Canada, [2]Biology, Queen's University, Kingston, ON, Canada. **Evolved tolerance to road salt among wild populations of *Daphnia* .**

Snowmelt and rain carry road salt from paved surfaces through the watershed via runoff and groundwater and increase the salinity of lakes, often measured as chloride concentration ($Cl^-$ mg/L). Salinization negatively impacts freshwater organisms, including *Daphnia pulicaria*, a ubiquitous crustacean zooplankton grazer that is integral to healthy ecosystems. *Daphnia* are sensitive to environmental changes, but studies have shown they are capable of rapid evolution. We investigated intraspecific variation in salt sensitivity among *D. pulicaria* collected from 10 lakes in southeastern Ontario to understand how wild *Daphnia* respond to salt pollution. Acclimation can also influence tolerance, so we tested the effect of acclimation on acute 48-hour salt tolerance for *Daphnia* grown at low (18 mg $Cl^-$/L) and high (218 mg $Cl^-$/L) $Cl^-$. Our results indicate that acclimation to salt does not significantly impact tolerance. Our common garden experiments testing acute toxicity of salt on *Daphnia* from lakes ranging from <1 mg $Cl^-$/L to 271 mg $Cl^-$/L show a wide range of salt tolerances for wild *Daphnia*. *Daphnia* from Presqu'ile Bay, Lake Ontario (26.2 mg $Cl^-$/L) and Lake Wilcox (194 mg $Cl^-$/L) have higher salt tolerances of 2222 mg $Cl^-$/L and 2344 mg $Cl^-$/L, respectively, compared to *Daphnia* from unimpacted lakes (1277 – 1617 mg $Cl^-$/L). This indicates that *D. pulicaria* may have adapted to localized road salt pollution. Understanding the factors contributing to robust tolerance to road salt will help inform decisions regarding freshwater ecosystem conservation.

**Casey Clunas**, Canadian Centre for Climate Services, Ottawa, ON, Canada. **Canadian Centre for Climate Services: Climate services and information for ecological adaptation.**

Climate services and information are key components of successful adaptation to climate change. However, finding and accessing the right data for the right purpose is a barrier to successfully using climate information in decision-making. The Canadian Centre for Climate Services (CCCS) was established to provide Canadians with information and support to consider climate change in their decisions. Attendees of this presentation will leave with an understanding of the data, tools, information and services available through the CCCS that are necessary to help understand, plan for the impacts of, and adapt to, climate change. Key services include the CCCS Website, where users will find high-level information on climate change and climate services and links to various data sources; and the Climate Services Support Desk, where users can get help from our climate service experts to find, understand, and use climate information. The presentation will also highlight ClimateData.ca, a user-friendly online climate data source, and the Map of Adaptation Actions, a repository of examples of adaptation actions from across Canada. The session will also be an opportunity to hear from attendees about potential variables of interest for potential inclusion on ClimateData.ca in the future.

**Jeanne Coffin-Schmitt**[1], Vivian M Nguyen[2], Richard Stedman[1], Leandro Castello[3] and Kathryn Fiorella[4], [1]Cornell University, Ithaca, NY, USA, [2]Carleton University, Ottawa, ON, Canada, [3]Virginia Tech,

Blacksburg, VA, USA, [4]College of Veterinary Medicine, Cornell University, Ithaca, NY, USA. **Self-provisioning from urban recreational fishing on the Niagara River.**

Provisioning food, nature, or community can all be valuable outputs from recreational fishing. There is a strong tradition of urban recreational fishing along the Niagara River in Buffalo, NY, USA even though it is a designated Area of Concern. This research aims to understand the scope of self-provisioning urban Great Lakes fishers in Buffalo, NY are doing, with a key focus on fish uses and the perceived risks and benefits of consumption. This case study focuses on urban fishers from one key urban fishing site to illuminate the needs of groups under-represented in fishery management and fish consumption policies. It is a part of a larger ongoing project looking at provisioning fishing around the Great Lakes. We are investigating (1) the underlying values placed on Great Lakes fishing and fish consumption by urban and immigrant communities in Buffalo, New York; (2) the suite of risks and benefits these communities are encountering, and (3) decision-making on whether, when, and how they self-provision with self-caught wild fish. Preliminary findings indicate that there is a very wide diversity of fisher groups, and an equally diverse set of perceptions of risks and benefits associated with a variety of fish consumption habits. However, most fishers shared that they value the intangibles they are provisioning as much or more than the fish they may choose to consume. This research highlights gaps and successes in fish consumption safety communication and the complex set of motivations that keep fishers committed fishing in an urban area with legacy contaminants.

**Cynthia Collier**[1], Louis J. Blume[2], Tim Lewis[1], Brick Fevold[1], Craig Palmer[1] and Molly Middlebrook[1], [1]GDIT, Falls Church, VA, USA, [2]USEPA Region 5 Great Lakes National Program Office, Chicago, IL, USA. **Using Great Lakes open data resources.**

This poster will present key data quality considerations to keep in mind when using data collected by others, as well as offer a list of Great Lakes data resources available to the public. More data is available than ever before from previous projects, monitoring programs, public databases, data feeds from remote sensors, published or unpublished research, and other sources. All shared data should be evaluated before being used, no matter how trustworthy the source. Prior to using data, determine what criteria the data must meet to allow you to reach your project objectives. Considerations may include what quality assurance and quality control the data has undergone, the level of precision and accuracy of the data, the temporal and spatial representativeness and completeness of the data, and the comparability or suitability of the methods used to collect or process the data. In addition to providing guidance on evaluating the quality of shared data, this poster may help you find data by providing a list of some of the data resources available across the Great Lakes. Do you know of a Great Lakes data resource others should hear about? Help us grow the list by stopping by to write down what data are offered and how to access it. This effort is funded under an EPA contract in support of the Great Lakes Restoration Initiative.

**Joseph K Connolly**[1], Christopher C Marshall[1], Patrick Hudson[2], James M Watkins[1], Anne E Scofield[3] and Lars G. Rudstam[1], [1]Cornell Biological Field Station, Bridgeport, NY, USA, [2]United States Geological Survey, Ann Arbor, MI, USA, [3]US Environmental Protection Agency, Chicago, IL, USA. **Reevaluation of the genus *Cyclops* in the Great Lakes: report of the exotic species *Cyclops divergens* from Lake Erie.**

Large cyclopoid copepods of the genus *Cyclops* are seldom collected in the Laurentian Great Lakes, with only *Cyclops scutifer* and *Cyclops strenuus* reported from the region. Rare reports of the species *C. strenuus* date back to 1972 within the Great Lakes basin. The first specimens reported as *C. strenuus* were collected from the St. Marys River, and additional specimens have been collected from western Lake Erie since 2013. We examined all available archived materials of *C. strenuus* from the Great Lakes and determined that specimens from the two localities belong to two separate species, neither of which refer to *C. strenuus*. Archived specimens collected from the St. Marys River in 1972 and 1995 were reidentified as *Cyclops sibiricus*, a Holarctic species known from Siberia, Russian Federation, Alaska, USA, and northern regions of Canada. The occurrences of *C. sibiricus* from the St. Marys River extend the known distribution of the species

southward some 1,688 km in the Nearctic region. *Cyclops* specimens collected from the western basin of Lake Erie in 2013, 2014, and 2019 were identified as the Palearctic species *Cyclops divergens* using both conventional taxonomy and genetic barcoding. *C. divergens* is known from localities across much of Europe and eastward into Central Asia. The occurrences of the species from western Lake Erie constitute the first detection of *C. divergens* in the Great Lakes and the Nearctic region. Therefore, we expect *C. strenuus* does not occur in the Great Lakes basin and is likely restricted to the Palearctic region.

**Andy Cook**[1], Richard Krauss[2], Matthew Faust[3], Joseph D. Schmitt[4], Alexis L Sakas[5], Yingming Zhao[6] and Christopher S. Vandergoot[7], [1]Ontario Ministry of Natural Resources and Forestry, Lake Erie Management Unit, Wheatley, ON, Canada, [2]USGS Lake Erie Biological Station, Huron, OH, USA, [3]Ohio Department of Natural Resources, Sandusky, OH, USA, [4]USGS Great Lakes Science Center, Lake Erie Biological Station, Huron, OH, USA, [5]The Nature Conservancy, Swanton, OH, USA, [6]Aquatic Research and Monitoring Section, Ontario Ministry of Natural Resources and Forestry, Lake Erie Fishery Station, Wheatley, ON, Canada, [7]Department of Fisheries and Wildlife, Michigan State University, East Lansing, MI, USA. **Lake Erie Whitefish Mortality Estimation Using Acoustic Telemetry.**

Lake Whitefish *Coregonus clupeaformis* experienced historic declines in Lake Erie due to habitat change, invasive species and exploitation. Recent declines were associated with poor recruitment, impacting Lake Erie fisheries. To study habitat use and Whitefish population characteristics, the Great Lakes Acoustic Telemetry Observation System (GLATOS) monitored movement and mortality of Lake Whitefish throughout Lake Erie and connecting waters. From 2015 to 2022, acoustic transmitters were implanted in 378 Lake Whitefish collected during fall spawning from 8 locations in western Lake Erie on reefs or near islands and staging areas. Lake Whitefish were also tagged with external tags indicating a $100 reward for the return of the internal transmitter. Estimated transmitter life ranged from 584 to 1825 days consisting of several models of new and recycled 69 kHz tags. From 2015 to January 2023, 47 transmitters were recovered from commercial fishers and 4 acoustic transmitters were recovered from beaches. Annual exploitation rates among tagging cohorts ranged from 0 to 20%. Unlike conventional methods dependent on tag reporting, acoustic telemetry estimates of survival were derived from detections over an extensive distribution of acoustic receivers. Quantifying survival and exploitation allowed direct estimation of fishing and natural mortality, in contrast with previously used indirect methods. Direct estimates of life history parameters may improve assessment and management of this data deficient species in Lake Erie.

**Clifton Coppolino**[1] and Karen McDonald[2], [1]Toronto and Region Conservation Authority, Woodbridge, ON, Canada, [2]Toronto and Region Conservation Authority, Vaughan, ON, Canada. **Gibraltar Point: restoring lost features, incorporating new ones, and preserving the Toronto Islands.**

Located at the southwest tip of the Toronto Islands, Gibraltar Point experienced long-term erosion exacerbated by severe storm events and lack of sand nourishment. Coastal analysis determined that without remedial action to address erosion over the next 20-25 years a breach in the point could occur, resulting in the significant loss of wetland habitat from the Toronto Island's inner lagoons. A Class Environmental Assessment identified the preferred alternative to be sand management with an offshore structure such as a breakwater. Later refinements proposed a nearshore reef off the west coast to anchor the imported sand brought to the shoreline to restore lost land. In 2022 the project was completed, which involved creating a 30,000 $m^2$ nearshore reef and importing 55,000 tonnes of sand to recreate a 2 Ha beach-dune system. Adaptive management by way of continued sand nourishment will be required every 5-10 years, as well as informed annual monitoring. While the project is just newly completed, the restored shoreline provides habitat opportunities for fish and wildlife, improving the ecological integrity of the Toronto Islands, and contributing to the de-listing of the Toronto AOC.

**Patricia Lynn Corcoran**, Emma Arnew, Jonathan Gijzen, Alexa Holland, Natalie Minda and Bethany Dean, Western University, London, ON, Canada. **Understanding the Sources and Transport of Micro- and Macroplastic Pollution in Suburban Stormwater Ponds.**

Stormwater ponds are anthropogenic aquatic basins designed to capture run-off during precipitation events. Each stormwater pond is engineered to contain a sediment forebay, berm, and main basin that all play a role in the movement of sediment and anthropogenic debris within and out the pond into natural aquatic environments. In London, Ontario, these environments are represented by above- and underground creeks that flow into the Thames River and eventually into Lake St. Clair of the Great Lakes watershed. We collected bottom sediment from twenty-eight stormwater ponds in the suburban areas of London, Ontario to determine the role the ponds play in retaining microplastic debris and in enabling identification of microplastic sources. We are also studying the macroplastic debris littering the shoreline of each pond and how the types, locations and abundances of microplastics relate to their larger counterparts. Finally, we are comparing the types of macroplastic debris across the city to determine if there is an influence of socio-economic status on the data. The results of this project are highly anticipated by key stakeholders, including the Upper Thames River Conservation Authority, The City of London, and the Deshkaan Zibing Anishinaabeg.

**Cecilia Cordero Oviedo**[1], Amanda Loder[2] and Sarah Finklestein[3], [1]University of Toronto, Department of Earth Sciences, Toronto, ON, Canada, [2]Canadian Wildlife Service, Environment and Climate Change Canada, Sackville, NB, Canada, [3]University of Toronto, Department of Geography, Toronto, ON, Canada. **Six thousand years of vegetation history from a mineral marsh on the Lake Erie sand plains.**

Mineral marshes in Great Lakes region provide critical habitat and are important carbon sinks, but many have been degraded. More data are needed to inform conservation and restoration. Here, we present a 4-m Middle - Late Holocene sediment record from a floodplain marsh in the central reaches of Big Creek. The record includes biological, sedimentological, and geochemical tracers, with the aim of reconstructing post-glacial vegetation history, identifying changes, and consequences of local and regional events on wetland functions. Wetland initiation took place ~5700 yrs ago, associated with high Lake Erie water levels of the Nipissing Phases. After that regional event, lake level and local water tables were less variable, and the river became the main source of sediments. Sediments were predominantly silty up to 2,700 yrs ago with sedge-dominated vegetation. After 1,800 yrs ago, sediment texture shifted to predominantly sand, likely reflecting patterns of channel meanders; thicket swamp communities dominated by *Cephalanthus* (buttonbush) expanded. The last 200 years reflect intensive disturbance during the settlement era. Pollen data show high abundances of taxa associated with disturbance and land-use change (*Ambrosia*, Poaceae, *Polygonum*) and accretion rates increase. This paleo-record contributes to the understanding of mineral marsh development and builds a baseline for restoration of wetlands affected by land conversion, invasive species and other practices altering ecosystem functions.

**Sophie Crevecoeur**[1], Lori Phillips[2], Jérôme Comte[3,4], Ngan Diep[5], Alice Dove[6], Thomas A. Edge[7], Thijs Frenken[8,9], Robert Michael McKay[8], Susan B. Watson[10] and Arthur Zastepa[11], [1]Water Science and Technology Directorate, Environment and Climate Change Canada, Burlington, ON, Canada, [2]Agriculture and Agri-Food Canada, Harrow, ON, Canada, [3]Centre Eau Terre Environnement, Institut National de la Recherche Scientifique, Quebec City, QC, Canada, [4]Groupe de Recherche Interuniversitaire en Limnologie et en Environnement Aquatique (GRIL), Université de Montréal, Montreal, QC, Canada, [5]Ontario Ministry of the Environment, Conservation and Parks, Etobicoke, ON, Canada, [6]Watershed Hydrology and Ecology Research Division, Environment and Climate Change Canada, Burlington, ON, Canada, [7]Department of Biology, McMaster University, Hamilton, ON, Canada, [8]Great Lakes Institute for Environmental Research, University of Windsor, Windsor, ON, Canada, [9]Cluster Nature & Society, HAS University of Applied Sciences, s-Hertogenbosch, Netherlands, [10]Department of Biology, Trent University, Peterborough, ON,

Canada, [11]Environment and Climate Change Canada, Burlington, ON, Canada. **Link between microbes involved in nutrient cycling and cHABs in Lake Erie watershed.**

Lake Erie is heavily impacted by urban and agricultural nutrient loading and faces recurring events of cyanobacterial harmful algal blooms (cHABs). Research focusing on abiotic drivers of cHABs, such as nutrients, continues to produce inconsistent results related to bloom prediction. Yet, there is increasing evidence that cyanobacteria are influenced by biogeochemical processes rendered by the greater aquatic microbial community (i.e aquatic microbiome), but those biotic factors and processes are rarely considered when studying cHABs. Here we used high throughput sequencing of the 16S rRNA gene and qPCR targeting genes involved in N and P cycling, to assess the taxonomic and functional diversity of the aquatic microbiome associated with cHAB events along the Thames River-Lake St. Clair- Lake Erie continuum, and across different seasons. We found that, throughout the year, genes involved in P acquisition and denitrification were in high abundance in the Thames River and Lake St. Clair, but decreased in abundance in Lake Erie. There were changes in the dominant cyanobacterial genera along the water continuum from April to October, and their relative abundance successively correlated with different genes involved in P or N cycling. Our results highlight the link between the changing microbiome, the microbial processes, and the presence and establishment of cHABs, which ultimately will help better understand the factors leading to their occurrence.

**Bernard Crimmins**, AEACS, New Kensington, PA, USA. **A Decade of Horizon Scanning for Contaminants in the Great Lakes.**

The legacy of polychlorinated biphenyls (PCBs) contamination is a stain on the role of the human species as stewards of the natural environment. Since the 1970s numerous chemicals have been detected that negatively impact the Great Lakes (and other) aquatic systems. The history of anthropogenic chemical contaminant detection in the Great Lakes spans the history of the US Environmental Protection Agency. Scientists continue to find new compound classes (e.g., polybrominated diphenyl ethers, polyfluoroalkyl substances, chlorinated paraffins) originating from the industrial chemical sector that are negatively affecting aquatic and human populations within the Great Lakes Basin. Since 2010, the US EPA funded Great Lake Fish Monitoring and Surveillance Program (GLFMSP) has been tasked with developing methods to proactively detect new problem chemicals in the Great Lakes. The chemical "Horizon" scan methodology has changed over the past decade due to advances in instrumentation, computational methods and data workflows. The current platform will discuss the history of emerging chemical screening in GLFMSP, lessons learned and new directions as we continue to improve efforts for effective chemical contamination horizon scan for the Great Lakes.

**Weijia Cui** and Carolyn Ren, University of Waterloo, Waterloo, ON, Canada. **Detection of microplastics in water system using an MXene based microwave sensor.**

Microplastic (MP) pollution has become an emerging environmental concern nowadays due to its difficulty to degrade and damage to human health. Facing the current threat of MP pollutions, there is a lack of MP sensing methods to sensitively monitor its level in water systems, and to realize on-site and quick MP detection. Herein, we demonstrate an MXene based microwave sensor for MP detection, which enables sensitive MP sensing relying on abundant functional groups on MXene surface. We synthesis the PDMS polymer complex containing MXene with abundant surface functional groups to benefit the absorption process for MPs, and find out the hydrogen bonding as the domain force in the absorption process. Different concentration of MPs are tested, and the proposed sensor can detect as low as 0.2 mg/ml MPs. Moreover, an on-site MP detection is carried out with the proposed sensor and compared with sensing results using laboratory-based devices.

**Kevin Czajkowski**[1], Janet Struble[1], Sara Mierzwiak[1], Michael Jabot[2], Amanda Gilbert[3], Mitchell Klett[4] and David Bydlowski[5], [1]Univesity of Toledo, Toledo, OH, USA, [2]SUNY-Fredonia, Fredonia, NY, USA, [3]Defiance College, Defiance, OH, USA, [4]Northern Michigan University, Marquette, MI, USA, [5]Wayne Regional Eduation Service Agency, Wayne, MI, USA. **Great Lakes Student Research Campaign: Engaging Students and Teachers in Authentic Watershed Studies.**

Five groups within the Great Lakes partnered together to develop a Great Lakes Student Research Campaign that was funded through the NOAA B-WET program. The goal of the project was to expand the engage students across the Great Lakes in authentic watershed experiences related to their local area and collaboratively across the Great Lakes. This project will engage teachers and students in Michigan, Ohio and New York through a partnership between the University of Toledo, Defiance College, Northern Michigan University, State University of New York (SUNY) at Fredonia and Wayne RESA in Wayne, MI. Each partner hosted up to five teachers in their local area. We offered a hybrid teacher Professional Development that utilized virtual training and face-to-face field work facilitated by their local partner utilizing GLOBE hydrosphere observations. Due to the pandemic, this approach served us well. GLOBE is an international program in 127 countries worldwide. Students take observations and enter the data on the GLOBE website that can be visualized freely on the internet. Students, a long-term classroom-integrated Meaningful Watershed Educational Experience, focused on developing research projects that they presented through an online student research symposium. The University of Toledo (UT) leveraged its NASA-funded, Science Activation grant for this project called GLOBE Mission EARTH, Fusing GLOBE with NASA Assets to Build Systemic Innovation in STEM Education.

# D

**Brittanie L Dabney** and Donna R Kashian, Wayne State University, Detroit, MI, USA. **Urban Stormwater Drainage Infrastructure Influences Microplastic Transport in Great Lake Tributaries.**

Stormwater effluent may be a major pathway of microplastic (MPs) contamination in Great Lake tributaries. However, it is still unclear the role of drainage infrastructure (e.g. surface drains and pipes) on the transport of MPs in freshwater systems. In this study, we measured MP concentrations at surface drains (pervious) and pipe (impervious) stormwater outfalls in the Clinton and Rouge River Watersheds in Michigan. The Clinton River watershed has more agricultural and forested areas and the Rouge River watershed has more residential and commercial developments. We also sampled upstream and downstream of the stormwater outfalls to determine the influence of outfalls on microplastic accumulation. At each sampling location, water and sediment samples were collected, as well as water quality parameters. Microplastics were extracted from samples and concentrations and morphology (sphere, fragment, fiber, or film). Results showed that fragments had the highest concentration in both water and sediment, followed by fibers. The highest MP concentrations were found mostly near pipe outfalls in both water and sediment. This study suggests that land use characteristics and the type of drainage infrastructure are useful for understanding MPs transport and may provide ecosystem managers the information required to design monitoring and remediation programs.

**Prasad Daggupati**[1], Avneet Singh[1], Pranesh Paul[1], Ramesh Rudra[1] and Pradeep Goel[2], [1]University of Guelph, Guelph, ON, Canada, [2]Ontario Ministry of the Environment, Conservation and Parks, Etobicoke, ON, Canada. **Bibliometric Analysis on Lake Erie and its Watershed.**

One-third of the Great Lakes region's people reside in the watershed of Lake Erie, and it satisfies drinking water needs of 11 million people in North America. Due to its warm shallow waters, it is the most ecologically diversified among all the Great Lakes. In recent decades, the lake's water quality has declined due to severe lake eutrophication. This study aimed to undertake a bibliometric examination of the evolution and present hotspots, contributions of authors, institutions, countries and keyword analysis of

Lake Erie basin's research by combining Web of Science and Scopus for bibliometric analysis on a total of 4297 research papers on Lake Erie and its basin that were published in 730 different sources. The first scientific publication on Lake Erie was discovered in 1885, and very few studies were published from 1885-1965. Over more than the last 130 years there was a shifting trend, and the upward trend started after 1970, which is closely related to the significant events in Lake Erie during those years. USA cooperated closely with Canada, and authors from both countries have dominated the research. Most of the articles were from The Journal of Great Lakes Research. An analysis revealed that during the recent decade, "dreissena polymorpha," "zebra mussel," "remote sensing," and "climate change" were the most emerging keywords, which show that recent attention has been placed on the application of novel technologies to understand the changes occurring in the Lake. **Keywords:** Bibliometric analysis, Zebra mussels, Lake Erie, Web of Science, Scopus, Biblioshiny

**Susan Daniel**, SUNY Buffalo State University, Buffalo, NY, USA. **Status of the New Zealand Mud Snail (*Potamopyrgus antipodarum*) in the Laurentian Great Lakes.**

The New Zealand Mud Snail (*Potamopyrgus antipodarum*) is an invasive species that was first reported in lakes Ontario in 1991, Erie in 2007, Michigan in 2006 and Superior in 2005. Subsequent studies of these populations indicate that specimens found within the Great Lakes are clones of a single female likely introduced via the ballast water of ocean-going freighters or the transportation of gamefish. To update the current status, distribution and habitats of this species in Great Lakes we combined data from the Great Lakes National Program Office (GLNPO) Biology Long-Term Monitoring Program (1998-2021) and Cooperative Science and Monitoring benthic surveys of Lakes Michigan (2015 & 2021), Ontario (2018), and Erie (2014 & 2019). Data from 2021 CSMI Lake Michigan survey indicate that *P. antipodarum* was the most abundant gastropod, comprising 93% of the total lake-wide gastropod density and 79% of biomass. *P. antipodarum* lake-wide density in 2021 increased 25-fold compared to 2015 and its occurrence increased 3-fold. We will explore the relationship between *P. antipodarum* and invasive Dreissenids as well as relationships across depth and substrate.

**Abram DaSilva**, James Noel and Brian Astifan, National Weather Service, Wilmington, OH, USA. **Using seasonal forecast ensembles to support harmful algal bloom forecasts at the NWS Ohio River Forecast Center.**

Harmful Algal Blooms (HABs) are an annual threat to millions of people living along the coast of Lake Erie; the toxins produced by these cyanobacterial blooms pose a risk to drinking water and negatively impact industries such as fisheries and tourism. Starting in 2016, the NWS Ohio River Forecast Center (OHRFC) has supported NOAA's National Centers for Coastal Ocean Science (NOAA/NOS/NCCOS) by providing daily Climate Forecasting System (CFS) 60-day flow forecasts. These forecasts for the Maumee River are used to improve predictions of phosphorus loading in their Lake Erie HAB forecast products. Recent introduction of the Hydrologic Ensemble Forecasting System, which can provide bias-correction for these hydrologic forecasts as well as give a longer lead time (90+ days), holds potential to further enhance these HAB products. In addition to describing these long-term flow forecasts and guidance products, this presentation will discuss how the OHRFC plays a role in helping with post-event analysis and the collaboration with NCCOS to improve the Lake Erie HAB forecasting process.

**Cody Catherine Dateno**[1] and Stuart Carlton[2], [1]Coastal & Great Lakes Social Science Lab / Illinois-Indiana Sea Grant, Purdue University Department of Forestry & Natural Resources, West Lafayette, IN, USA, [2]Illinois-Indiana Sea Grant/Coastal & Great Lakes Social Science Lab, Purdue University Department of Forestry & Natural Resources, West Lafayette, IN, USA. **Attitudes, risk perceptions, and behaviors toward aquatic invasive species among boaters in Illinois and Indiana.**

Aquatic invasive species (AIS) have transformed the ecology of the Great Lakes and remain a major threat to the health and biodiversity of the lakes. Recreational boating is a major vector of potential invasions as many boaters do not consistently perform the recommended steps to help prevent the spread of AIS. Although there is relatively high awareness of AIS among boaters, there is a gap between boater awareness and boater preventative actions. Understanding boaters' attitudes, risk perceptions, and behaviors toward AIS can help resource managers and outreach staff design effective policies, communications products, and outreach interventions to address this gap. Although there has been past qualitative and quantitative research done on these questions, there is a need for additional research in some of the under-studied Great Lakes states. To address this need, we conducted an online survey of registered boaters in Illinois and Indiana and asked them about their attitudes, risk perceptions, and prevention behavior toward AIS. Our results elucidate key drivers of AIS prevention behaviors and offer suggestions for how to successfully communicate about this critical issue.

**Benjamin Davidson**[1], Kallyn Batista[1], Sabeel Samrah[1], Lorena M Rios Mendoza[2] and Nimish Pujara[1], [1]University of Wisconsin - Madison, Madison, WI, USA, [2]University of Wisconsin - Superior, Superior, WI, USA. **Microplastic contamination of beach sediments: unpacking trends across three sites in western Lake Superior.**

Microplastic pollution has spread throughout the globe, and the Great Lakes ecosystem is no exception to this contamination. Previous work has shown that beaches act as sinks for aquatic microplastic pollution, but the processes and extent of the collection of microplastic debris on beaches is not well understood. We consider the microplastic concentration in beach sediments in three dimensions by isolating microplastics from sediments with varied alongshore and cross shore locations and depth. We analyze beach sediments from three western Lake Superior beaches with various proximity to suspected microplastic sources of the St. Louis River estuary and a wastewater treatment plant. We find recovered microplastics to be dominated by polyester fibers. We also show that microplastic concentration in beach sediments does not significantly depend on the proximity of the beach to a suspected microplastic source.

**Michele DellAquila**[1], Krista M. Chomicki[2], Chris T Parsons[3] and Andrea E. Kirkwood[4], [1]Ontario Tech University, Oshawa, ON, Canada, [2]Toronto and Region Conservation Authority, Vaughan, ON, Canada, [3]Canada Centre for Inland Waters, ECCC, Environment and Climate Change Canada, Burlington, ON, Canada, [4]Faculty of Science, Ontario Tech University, Oshawa, ON, Canada. **Investigating the role of anoxia in the nutrient dynamics of four Lake Ontario coastal wetlands.**

Although Great Lakes coastal wetlands are considered "keystone" ecosystems, surprisingly little is known about their dynamic role in regulating nutrient loadings to receiving waters. Based on over a decade of spatially explicit monitoring, the Toronto and Region Conservation Authority determined that four coastal wetlands (Rouge Marsh, Duffin's Marsh, Carruthers Marsh, and Frenchman's Bay) vary in their capacity to be net-sinks or net-sources of phosphorus to Lake Ontario. To improve our understanding of phosphorus fate and dynamics in these coastal wetlands, we deployed continuous (every 30 min) multiparameter (dissolved oxygen, conductivity, turbidity, pH) sondes just above the sediment surface in each study wetland for eight weeks (Aug. – October) in 2022. A suite of phosphorus and nitrogen samples were collected weekly with other water quality variables. We will present these findings with an emphasis on the role of dissolved oxygen and nitrate concentrations in mediating internal phosphorus loading.

**Emilie DeRochie**, Great River Rapport, River Institute, Cornwall, ON, Canada. **The Great River Rapport's Change Maker Series: Engaging youth to make change for local ecosystems.**

Introducing the Change Maker Series, an educational initiative that aims to inspire youth through multi-media narratives about individuals making a difference along the Upper St. Lawrence River. The series is part of a larger project called the Great River Rapport, a collaborative, community engaged ecosystem

health report for the Upper St. Lawrence. This project, in partnership with Mohawk Council of Akwesasne, weaves scientific data together with stories, Indigenous perspectives, and photography to convey science in formats that are accessible and meaningful for diverse audiences. The Great River Rapport's Change Maker Series features Change Makers – individuals with diverse backgrounds, experiences, and interests who share a common commitment to the environment. For each Change Maker, the series includes (1) a case study, accompanied by photographs and art, that narrates the individual's life journey and relationship to the environment, the actions that they have taken to make change, and their future goals;(2) a learning activity that encourages youth to put themselves in the shoes of the individual; and (3) a full lesson plan for teachers. All of these materials will be accessible through the Great River Rapport website. The learning activities range from creating a podcast with a change making message, to role-playing different stakeholders in an ecological restoration project. These activities use multi-media components to engage and inspire modern change makers and are designed to be relevant to youth around the world.

**Heather D. Dettman**, Natural Resources Canada, Devon, AB, Canada. **Temperature effect on oil spill behaviour and biodegradation – meso-scale studies of diluted bitumen.**

Petroleum product spills in freshwater environments can have different fates and behaviours depending on the type of product and the conditions of the spill. The composition of the oil and water temperature strongly affect how much of the oil can evaporate, dissolve, and be biodegraded. The water temperature, sediment loading, and wave/current energy will affect how much of the oil can sink to contaminate bottom sediment. Climate change is expected to increase both the frequency and intensity of major weather events in the Great Lakes Region. When flooding occurs, the unusual conditions make prediction of oil spill behaviour difficult. This presentation will describe the compositions of petroleum products, and their potential biodegradability. Detailed results will be presented from meso-scale freshwater spill tests to illustrate how temperature affects the behaviour and microbial response to oils such as diluted bitumen. Approaches to mitigate oil spill impacts will be suggested to support oil spill response.

**Jaskaran Dhiman**[1], Pranesh Paul[1], Ramesh Rudra[1], Prasad Daggupati[1], Shiv Prasher[2] and Pradeep Goel[3], [1]University of Guelph, Guelph, ON, Canada, [2]McGill University, Montreal, QC, Canada, [3]Ontario Ministry of the Environment, Conservation and Parks, Etobicoke, ON, Canada. **Modification of SWAT model for improved winter hydrology simulation in the Great Lakes Basin.**

High phosphorus levels in Lake Erie that have resulted in the formation of harmful algal blooms and dead zones, highlight the need of coordinated and strategic responses to nutrient management issues in the Great Lake Regions. Recent modeling and monitoring studies in the basin have indicated that the winter and early spring season has become the peak period for phosphorus loads from non-point sources. Following the identification of areas for improvement within the SWAT model for better winter hydrology simulation, the model was modified through use of machine learning based model for improved soil temperature estimation. The modified model yielded better streamflow prediction accuracy as compared to the original model for Gully Creek Watershed within the basin. We also developed an improved soil erodibility module within the SWAT model in conjunction with the modified SWAT model developed by researchers from the Faculty of Forestry and Environmental Management, University of New Brunswick, based on published data regarding seasonal erodibility of commonly found soils in Southern Ontario. This component is currently being finalized within the modified SWAT model to enhance simulation of seasonally variable soil erosion rates in Southern Ontario. The development methodology, as well as the results of model application will be presented.

**Miriam L Diamond**[1,2], Scott Mundle[3], Razegheh (Raz) Akhbarizadeh[2], Julian Aherne[4], Patricia Lynn Corcoran[5], Maria B. Dittrich[6], James Gauld[7], Paul Helm[1,8], Liisa M Jantunen[9], Bulent Mutus[7], Elodie Passeport[10] and Simon Rondeau-Gagne[7], [1]School of the Environment, University of Toronto, Toronto,

ON, Canada, [2]Department of Earth Sciences, University of Toronto, Toronto, ON, Canada, [3]Great Lakes Institute for Environmental Research, University of Windsor, Windsor, ON, Canada, [4]Trent University, Peterborough, ON, Canada, [5]Western University, London, ON, Canada, [6]University of Toronto Scarborough, Toronto, ON, Canada, [7]Department of Chemistry and Biochemistry, University of Windsor, Windsor, ON, Canada, [8]Environmental Monitoring and Reporting Branch, Ontario Ministry of the Environment, Conservation and Parks, Toronto, ON, Canada, [9]Air Quality Processes Research Section, Environment and Climate Change Canada, Egbert, ON, Canada, [10]Department of Civil & Mineral Engineering University of Toronto, Toronto, ON, Canada. **Source-specific identification, characterization, and control of MPs across a remote, rural and urban gradient.**

In the context of the widespread occurrence of microplastics (MP) in the Canadian environment, our project aims to support the adoption of effective MP mitigation policies based on understanding sources, pathways, and evaluating selected control strategies. We have 4 approaches. (1) We are developing new analytical tools to enable MP identification and classification, including developing high affinity MP ligands to allow for sensitive and specific MP identification in complex media (Awada et al. 2022). (2) We are investigating air, water and soil transport pathways, total loadings and source contributions across remote (Dorset), agricultural (Thames River), and urban (Etobicoke Creek) watersheds in Ontario. A necessary prerequisite is developing replicable, repeatable and representative harmonized sampling and sample preparation methods. Here, we are evaluating four air sampling methods, comparing and testing water sampling methods, and developing optimized sample preparation methods involving digestion procedures. (3) We are testing mitigation measures, namely Litta Traps and bioretention cells, both of which are intended to capture MPs in stormwater and that are proving to be useful methods. (4) We are developing a knowledge network that includes private and public sector stakeholders that could implement innovations and/or best practices arising from the study.

**Emilia DiBiasio**, Cleveland State University, Cleveland, OH, USA. **Analyzing spring carbon dynamics across the nearshore-offshore boundary of lake Erie off the Cleveland coast.**

Lake Erie provides a unique ecosystem to observe $CO_2$ fluxes among different interfaces of the environment. Parameters such as $pCO_2$ and $\delta^{13}C_{DIC}$ have a dynamic relationship which is of most interest off the Cleveland coast, where the boundary between the nearshore and offshore environments exists. Samples from the nearshore-offshore interface were collected in the spring of 2022 and analyzed for $\delta^{13}C_{DIC}$, DIC and other values. Trends in $\delta^{13}C_{DIC}$ exhibited an influence of tributary input during the mixing season. Values as low as -2.2‰ in the nearshore were found from values as high as -0.2‰ in the offshore (spring mean -1.3‰). Mean DIC concentrations amounted to 22.7 mg/L for the extent of the sampling zone. DIC concentrations increased slightly from the nearshore to the offshore. Spring $\delta^{13}C_{DIC}$ values of the offshore are greater than values in the western basin (spring mean -3.1‰) and lower than those presented from Karim and Desai, 2011, during summer months (summer basin mean 0.2‰). We expect to see increases in $\delta^{13}C_{DIC}$ during the stratification season as the surface water reaches $pCO_2$ equilibrium. These results will be compared to $pCO_2$ as derived from water quality data from U.S. EPA and other agencies to develop a context of seasonal to decadal change in carbon dynamics across the nearshore offshore boundary of lake Erie.

**Matthew W. Diebel**, Matthew A. Pronschinske, Matthew J. Komiskey and Luke C. Loken, U.S. Geological Survey, Upper Midwest Water Science Center, Madison, WI, USA. **Stream nutrient changes with intensive implementation of agricultural conservation practices.**

The Great Lakes Restoration Initiative Priority Watersheds program is an effort to reduce nutrient loading to the Great Lakes by implementing conservation practices and tracking progress in water quality. Nutrient concentrations and stream discharge were intensively monitored at six streams within four priority watersheds (Fox River, Saginaw River, Maumee River, Genesee River) between 2012 and 2021, and then two methods were used to evaluate water quality changes. The first method used generalized additive

models (GAM) to test for step changes in nutrient concentrations and loads during runoff events while controlling for precipitation, antecedent discharge, and season. To complement this analysis, gradual changes in flow-normalized concentration-discharge relationships were evaluated over the monitoring period with Weighted Regressions on Time, Discharge, and Season (WRTDS). A comparison of the results of the step-change and WRTDS analyses revealed an important distinction between the two approaches. The GAM models control for weather drivers and can therefore reflect changes in factors that affect runoff generation, such as interception and infiltration, whereas the WRTDS models control for discharge and therefore only reflect changes in nutrient sources and transport. Because all these factors may be affected by agricultural conservation practices, the two modeling approaches are complementary and provide a more nuanced understanding of conservation effectiveness.

**Alicia Doberstein**, University of Wisconsin-Milwaukee, School of Freshwater Science and Applied Technology, Milwaukee, WI, USA. **Bathymetric Study of Laguna Bacalar Quintana Roo Yucatan Peninsula.**

Located in the southeast corridor of the Yucatan Peninsula, Mexico's second largest freshwater lake, Laguna Bacalar (approximately 50 km long by 1 km wide) is nested within a complex hydrogeographic system with a network of karstic underwater streams and cenotes. Known widely for the historic water clarity and colloquially referred to as "La Laguna de los 7 colores" or "The Lagoon of 7 colors", this transboundary system has spurred a growing tourism industry and fuels economic development within the region. In June 2020 Tropical Storm Cristobal dropped roughly half a meter of rainfall over a few days and triggered a massive runoff event that turned much of the laguna turbid for several months. At that time there was little scientific information on the hydrology, the water mass balance, or water residence times for the Laguna. In 2022, using georeferenced fathometry, the first detailed bathymetric chart was developed via several hundred kilometers of track line conducted over a period of 5 weeks. This study provided the first estimate of the volume of the lake, which when combined with measurements of tributary surface water inflow and outflow allowed the calculation of water residence times for its main basins. Unmeasured subsurface groundwater inflow and outflow will lower the calculated residence times. Residence time is a key to understanding the impact of natural and anthropogenic inputs to the laguna and will assist with making data-based land-use decisions to reduce the environmental risks to the Laguna that sustains much of the areas human and ecological livelihood.

**Sarah Dobie**, University of Michigan, Ann Arbor, MI, USA. **Defining coastal resilience in the Great Lakes: A systematic review and critical comparison.**

There are many definitions of resilience, and a growing body of literature suggests that how resilience is defined may have significant consequences for planning and policy making outcomes. In the Great Lakes Region, resilience is gaining increasing attention from planners and policy makers in response to more frequent disruptions to social-ecological systems and built environments from coastal hazards. There has not yet been extensive research into how resilience is being defined in practice and how these definitions can affect geographies of risk and resilience and contribute to varying ecological, social, cultural, political, and economic outcomes. This research analyzes how stakeholders engaged in natural resource management activities within the Laurentian Great Lakes coastal environment define resilience and discuss the implications for planning and policy making through a critical geography and critical space lens. The analysis consists of two parts: 1) a systematic review of gray literature published by these stakeholders to document definitions of resilience; and 2) an analysis of these definitions using a 5Ws + H of resilience framework—resilience for whom, what, where, when, why, and how. This research reveals two gaps that could affect ongoing regional planning and policy making efforts, as well as four research needs to address these gaps and inform planning and policy making going forward.

**Margaret F. Docker**[1], Colin J. Garroway[1], Phil D. Grayson[1,2], Sara V. Good[1,3], Alison E. Wright[4] and Tamanna Yasmin[1,5], [1]University of Manitoba, Winnipeg, MB, Canada, [2]Beam Therapeutics, Cambridge, MA, USA, [3]University of Winnipeg, Winnipeg, MB, Canada, [4]University of Sheffield, Sheffield, United Kingdom, [5]University of British Columbia, Vancouver, BC, Canada. **Sex determination in sea lamprey: One small step towards genetic control in the Great Lakes.**

The sea lamprey is an invasive pest in the Great Lakes. Sex-ratio distortion systems for pests are highly effective once other control measures have reduced abundance, so genetic manipulation of sex ratios is being investigated as a complement to existing sea lamprey control. However, a genetic basis for sex determination in lampreys remains elusive. Environmental sex determination (ESD) has been suggested, but the evidence is equivocal, and no fish species with only ESD is known. Using a two-pronged genomics and transcriptomics approach, we suggest that the germline-specific region (GSR) of the genome, the part jettisoned from somatic cells during embryonic development, holds the key. 1) Using whole genome sequences from fin clips of >200 sea lamprey, we found no sex-specific differences in the somatic genome. 2) However, analyzing RNA-sequence data from gonads sampled across developmental stages, we identified 638 germline-specific genes that are highly expressed only in males, and putative orthologs of some of these genes have known functions in sex determination and differentiation in other vertebrates. We conclude that the GSR plays an important role in testicular differentiation, and we propose a mechanism for how environmental and genetic factors work together to control lamprey sex.

**Erica Doody**[1], Anne E Scofield[2] and Matthew Pawlowski[2], [1]US EPA GLNPO - ORISE, Chicago, IL, USA, [2]US Environmental Protection Agency, Chicago, IL, USA. **Trends in particulate nutrient concentrations and seston stoichiometry of the Laurentian Great Lakes.**

Offshore particulate matter is typically planktonic in origin; changes in concentrations and elemental ratios can reflect surrounding ecological conditions and aid in assessing ecosystem health. The EPA's Great Lakes National Program Office has collected particulate nutrient data in both spring and summer from all five of the Laurentian Great Lakes since the late 1990s. Here, we present a cross-lake comparison of temporal trends in particulate phosphorus (PP), particulate nitrogen (PN), particulate organic carbon (POC), total suspended solids (TSS), and seston stoichiometry (N:P) from 1997 – 2019. Significant spring trends over the full time series include increased PP in Lake Superior, increased PN in central and eastern Lake Erie, decreased PP, PN, POC and TSS in Lake Huron, and decreased PP and TSS in southern Lake Michigan. The only significant trends in summer data were declines in epilimnion PP and TSS in Lake Michigan. After over a decade of general declines, PN concentrations across most lakes started increasing in 2012, with a significant break point in that year for lakes Superior, Huron, Michigan, and Ontario. Particulate N:P has changed in recent years, indicating possible nutrient deficiency in the lower food web, and the recent changes may hint at declining seston nutritional quality. We also compare particulate nutrient temporal patterns to the timing of significant ecological changes in the Great Lakes, including the expansion of dreissenid mussel populations, declines in the spring phytoplankton bloom, and changes to the zooplankton community.

**Jared Dorvinen**, W.F. Baird & Associates, Madison, WI, USA. **A nature-based approach to the restoration of an industrially impacted shoreline on Lake Superior.**

Using a nature-based and inter-disciplinary approach, a restoration plan was created for an industrially impacted shoreline in Marquette, Michigan. This plan includes the restoration of ~5 hectares of dune and swale uplands and construction of a new "living revetment" along 950 meters of shoreline. Together these features provide erosion and flood protection for the shoreline along the project site while also enhancing public access, creating valuable coastal habitat, and minimizing impacts to an existing contaminated groundwater plume. The design of the "living revetment" is based on the form and function of natural cobble beaches commonly found on Lake Superior. The flexible nature of this design allows it to dynamically adjust to changing water-levels and wave conditions, thereby enabling the structure to

adaptively respond to the current and future effects of climate change without human intervention. Once constructed, this will be one of the first engineered structures of its type in the Great Lakes region and through post-construction monitoring it will become a valuable demonstration project to inform the design of similar structures in the future. Despite being an established shoreline management practice in various parts of the world and providing many benefits over traditional hard armoring techniques, constructed cobble shorelines are still a novel approach in the Great Lakes region. The wider adoption of this technology will require a paradigm shift in our collective approach to managing the publicly held bottomlands of the Great Lakes shoreline.

**Nate Drag**, New York Sea Grant, Buffao, NY, USA. **Using Great Lakes research data in K-12 education to connect students with the Great Lakes and increase data literacy.**

Throughout the education system, teachers, educators, and students are looking for connections with the real world that are relevant and impactful. At the same time, there is an urgent need for students to develop data literacy skills, like collecting, analyzing, summarizing, and communicating data, as part of the Next Generation Science Standards (NGSS). Data from current Great Lakes research projects can stimulate student curiosity, lead to question generation, and inform students on how to collect data themselves. Additionally, pairing this data with the story of the scientists who collected it can also impact student interest in science, science careers, and scientific self-efficacy. However, this data must be shared with students, as well as their teachers and educators, in an accessible and effective manner. In this presentation, New York Sea Grant Great Lakes Literacy Specialist Nate Drag will discuss the role Great Lakes research data can play in classrooms in the context of Next Generation Science Standards, describe the need for increased data literacy skills in students, and illustrate how Great Lakes research data can fit into these roles when presented in an accessible format. The presentation will then provide tips, techniques, and examples of successful data sharing and usage in classrooms and educational programs.

**Yvonne Drebert**[1], Zach Melnick[1], Erin S. Dunlop[2] and Andrew M Muir[3], [1]Inspired Planet Productions, Miller Lake, ON, Canada, [2]Ontario MNRF, Trent University, Peterborough, ON, Canada, [3]Great Lakes Fishery Commission, Ann Arbor, MI, USA. **You Can Leave the Light On: Observing Coregonine Spawning Behaviour in Real Time with ROVs.**

Owing to their aquatic nature and late fall breeding, coregonine spawning activity in a natural environment remains undocumented in the scientific literature. This knowledge gap inhibits understanding of how recent declines in coregonine recruitment are linked to spawning behaviour. With the latest innovations in remotely-operated-vehicle (ROV) and ultra-lowlight camera technology, we filmed pre-spawning and spawning behaviours in several coregonine species in the natural environment, without the limitations imposed by other research techniques. While certain species, such as lake whitefish, showed behavioural responses to the ROV at other times of year, during the spawning season they appeared indifferent to the craft, even when it was illuminating the environment with white light. ROV footage captured on the evening of November 24, 2022 at a spawning shoal in Lake Michigan observed a group of lake whitefish swimming slowly on top of rocky substrate covered with dreissenid mussels. Rubbing activity (i.e., body contact and nudging) within the group (including contact with the ROV), was recorded. Two presumed females were filmed, often swimming close to the substrate and oriented slightly downward. A large female was slowly followed by several presumed males, gamete release was observed between an individual male and the female in a vertical "dance." Our work proves the effectiveness of ROVs as a tool for observing coregeonine behaviour and provides new information to inform habitat restoration and study coregonine recruitment.

**Ken G Drouillard**[1], Linda Campbell Campbell[2], Dennis Otieno[3], George S. Bullerjahn[4], Kefa Otiso[4], Robert Michael McKay[1], Albert Getabu[5], Ted J Lawrence[6], James Nijru[3], Reuban Omondi[5], Bethwell Owuor[5],

Anakalo Shitandi[5], Lewis Sitoki[7], Emma Tebbs[8], Dorine Achieng[9], George Basweti[9], Katelyn Barker[9], Max Beal[9], Katelyn Brown[9], Aidan Byrne[9], Linet Imbayi[9], Davide Lomeo[9], Jared Miruka[9], Samantha Mohney[9], Kaela Elizabeth Natwora[10], Mark Olokotum[9], Argwings Owino[9], Winnie Owoko[9], Jordyn T Stoll[11], Emily Marcella Varga[9], Ryan Wagner[9] and Brittany N. Zepernick[12], [1]Great Lakes Institute for Environmental Research, University of Windsor, Windsor, ON, Canada, [2]Saint Mary's University, Halifax, NS, Canada, [3]Kenya Marine and Fisheries Research Institute, Kisumu, Kenya, [4]Bowling Green State University, Bowling Green, OH, USA, [5]Kisii University, Kisii, Kenya, [6]International Institute for Sustainable Development, Winnipeg, MB, Canada, [7]Technical University of Kenya, Nairobi, Kenya, [8]King's College London, London, United Kingdom, [9]NSF-IRES Lake Victoria Research Consortium, Bowling Green, OH, USA, [10]University of Minnesota - Duluth, Two Harbors, MN, USA, [11]Kent State University, Vermilion, OH, USA, [12]University of Tennessee, Knoxville, TN, USA. **Temporal trends of mercury and isotopes in Nile Perch from Winam Gulf, Lake Victoria, Kenya: 1998 vs 2022.**

Nile Perch were obtained from Winam Gulf of Lake Victoria in 1998 and 2022. Thirty eight and 43 perch samples ranging in total length from 1.2 - 158 cm and 7.7 to 139.5 cm were processed in 1998 and 2002, respectively. A smaller number of samples of nile tilapia and unionids were co-collected across years. Samples were analyzed for $\delta^{13}C$ and $\delta^{15}N$ stable isotopes and total Hg. Carbon isotopes were depleted in mussel, tilapia and perch in 2022 compared to 1998 but $\delta^{13}C$ was independent of body size for both fish species. Nitrogen isotopes were not dependent on size for tilapia (1998) but strongly size dependent for perch (1998 and 2022). For size matched tilapia, $\delta^{15}N$ decreased in 2022 with a similar, but non-significant temporal decrease observed for perch. Total Hg showed a significant decrease in tilapia in 2022 compared to 1998. For perch, the bioaccumulation slopes of Hg vs total length and Hg vs $\delta^{15}N$ were significantly different between years with higher bioaccumulation rates observed in 2022. These shifts were most evident in large perch > 80 cm and highest trophic level fish. Total length was a stronger predictor of Hg ($R^2$ of 0.45 and 0.86 for 1998 and 2002 ) compared to $\delta^{15}N$ ($R^2$ of 0.07 in 1998 and 0.52 in 2002). Risk analysis on the legal 50 to 85 cm commercial slot size indicates a shift in maximum recommended monthly meals from >32 meal/month in 1998 to 16 meal/month for perch over 70 cm in length for women of childbearing age and children.

**Zhongzhao Duan**[1,2], Wei Gao[3] and Xuexiu Chang[4], [1]School of Ecology and Environmental Sciences & Yunnan Key Laboratory for Plateau Mountain Ecology and Restoration of Degraded Environments,Yunnan University, Kunming, China, [2]College of Agronomy and Life Sciences, Kunming University, Kunming, China, [3]Guangdong Provincial Key Laboratory of Water Quality Improvement and Ecological Restoration for Watersheds, School of Ecology, Environment and Resources, Guangdong University of Technology, Guangzhou, China, [4]College of Agriculture and Life Sciences, Kunming University, Kunming, China. **Varying hydrological response to climate change in three neighborhood Chinese plateau lake basins.**

Climate change and its impact on plateau lakes are of wide concern in China owing to their diverse yet fragile ecosystem functions. The three largest and most concerning plateau lakes (Dianchi, Erhai, and Fuxian lakes) in southwestern China were selected as case studies to demonstrate their different hydrological responses attribute to the local climatic and watershed characteristics. The daily runoff of each lake basin under the historical and 27 climate change scenarios were simulated. The results showed that: The mean annual runoff of the Lake Dianchi Basin (LDB), Lake Erhai Basin (LEB), and Lake Fuxian Basin (LFB) changed by –43.00 to 34.08 %, –49.28 to 35.88 %, and –65.24 to 54.17 %, respectively, when the air temperature increased by 1–2 ℃ and precipitation changed by –20 to +20 %. Each lake basin responded differently to climate change, among them, the LFB was more sensitive to climate change than the LDB and LEB. Changes in the annual and seasonal runoff for the LFB were approximately 1.5-fold higher than that of the LDB and LEB. The hydrological extremes in the LFB also had the most significant changes. Climate change significantly altered the water resources of each lake basin, and future climate change may pose

specific yet serious socio-economic or ecological risks to each lake, therefore, each lake requires reasonable and effective mitigation measures.

**Hilary Dugan**[1], Chris T Solomon[2], William D Hintz[3] and Suart E Jones[4], [1]Center for Limnology, University of Wisconsin-Madison, Madison, WI, USA, [2]Cary Institute of Ecosystem Studies, Millbrook, NY, USA, [3]The University of Toledo, Toledo, OH, USA, [4]University of Notre Dame, Notre Dame, IN, USA. **Upper bounds of chloride concentrations in the Laurentian Great Lakes watershed.**

In the Great Lakes watershed, numerous streams and lakes are threatened by chloride pollution. Here, we construct a simple model to predict the upper bounds of road salt concentrations in inland lakes and the Great Lakes. Our model suggests that equilibrium salt concentration depends on three quantities: salt application rate, road density, and net precipitation. We apply the model using spatially explicit data in the Great Lakes watershed. We predict equilibrium road salt concentration for all lakes larger than 1 ha in the contiguous United States and greater than 10 ha in Canada. We find that for the vast majority of lakes, chloride concentrations will stay below regulatory thresholds. Further, we can apply the model to predict return times to lower chloride concentrations across a range of road salt reduction scenarios. Our results help to contextualize trajectories in road salt pollution of lakes, and the role management practices will play in maintaining or reducing current chloride concentrations.

**Nate M. Dugener**[1], Ian P. Stone[2], Tony D. Weinke[1] and Bopi A. Biddanda[1], [1]Grand Valley State University, Muskegon, MI, USA, [2]University of Michigan, Ann Arbor, MI, USA. **Variability in hypoxia severity is linked to temperature and precipitation in a Great Lakes estuary.**

Hypolimnetic hypoxia is expanding globally due to climate warming and eutrophication. Muskegon Lake, a Great Lakes estuary and EPA area of concern that is close to being delisted, experiences annually recurring hypoxia, putting its ecological and economic benefits at risk. We utilized high-frequency Muskegon Lake Observatory (MLO) buoy water quality and meteorological data (https://www.gvsu.edu/wri/buoy/) to examine the dynamics of hypoxia during 2011-2021. We developed a hypoxic severity index to estimate the annual severity of hypoxia based on the number of days of hypoxia and hypolimnetic dissolved oxygen concentrations. Warmer winter and spring temperatures correlated with higher hypoxic severity, such as 2012 and 2021, while high spring precipitation and watershed discharge correlated strongly with a lower severity of hypoxia, such as 2015 and 2019. There was no clear pattern of hypoxia or water temperatures increasing or decreasing significantly over the decade. Rather, examining the environmental conditions prior to the onset of hypoxia may help predict the potential severity of hypoxia for any particular year. Our findings suggest that temperature and precipitation are major drivers of hypoxia with relevance for similarly impacted estuaries and coastal waters, showing the need for continued time-series monitoring.

**Ruth Duncan**[1,2], Erin S. Dunlop[3], Camilla Ryther[2], Ryan Lauzon[4] and Mary-Claire Buell[5], [1]Collective Environmental, Peterborough, ON, Canada, [2]Trent University, Peterborough, ON, Canada, [3]Ontario MNRF, Trent University, Peterborough, ON, Canada, [4]Chippewas of Nawash Unceded First Nation, Wiarton, ON, Canada, [5]Collective Environmental / Trent University, Peterborough, ON, Canada. **The Bim'mazh Project: Dikameg (Lake Whitefish), Technology and Saugeen Ojibway Nation Ecological Knowledge.**

Since time immemorial the Saugeen Ojibway Nation (SON) has harvested dikameg (lake whitefish), which has developed into a strong cultural connection and understanding of these fascinating fish. Over the past two decades, Lake Huron has drastically changed resulting in the decline of dikameg. Dikameg play an important role in the ecosystems of Lake Huron, and for the SON dikameg is central to ceremony, trade, and subsistence. The Bima'azh project is using education, technology, Western science, and SON ecological knowledge (SONEK) to address community concerns around the decline of dikameg and in doing so,

protect SON's Indigenous Treaty Rights. The Bima'azh project also provides a clear example of research that achieves equitable inclusion of both Western and Indigenous systems of knowledge. Led by the SON fisheries offices, we challenge the status quo of fisheries research by ensuring SONEK and values are central to our project design, implementation, and interpretation. The application of a Two-Eyed Seeing approach within this project creates an example of a holistic and equitable approach to research that is important to share with the Great Lakes Community. Ultimately the Bima'azh Project provides an example of how Two-Eyed Seeing research can inform decision-making; ensuring dikameg thrive for the next seven generations.

**Alexander Duncan**[1], **Elizabeth Nyboer**[2] and Andrea Reid[2], [1]University of British Columbia, Vancouver, BC, Canada, [2]Centre for Indigenous Fisheries, University of British Columbia, Vancouver, BC, Canada. **Listening to rightsholders: Research and stewardship of sea lamprey in the Laurentian Great Lakes.**

The control of invasive sea lamprey is a complex process that involves multiple sovereign nations and various jurisdictions throughout the Laurentian Great Lakes. Represented within this are diverse Tribes (U.S.) and First Nations (CAN) who have inherent rights to lands and waters and hold distinct perspectives, experiences, and visions for how the Great Lakes should be treated and cared for. These understandings and sources of expertise are currently underrepresented, and often actively excluded from decision-making processes around aquatic resources in the Great Lakes system. Research priorities, articulated in (and beyond) the literature, emphasize the need for Indigenous-led research and for Indigenous perspectives and values to inform decision-making and successful, equitable management of aquatic resources. A novel project seeks to document Indigenous perspectives and experiences with sea lamprey and their control within the Great Lakes. We will share this project's impetus and framing, and discuss early directions and outcomes.

**Erin S. Dunlop**[1], Issac Hebert[1] and Katelyn Cunningham[2,3], [1]Ontario MNRF, Trent University, Peterborough, ON, Canada, [2]Trent University, Peterborough, ON, Canada, [3]Carleton University, Ottawa, ON, Canada. **Larval lake whitefish dynamics in Lake Huron.**

Lake whitefish stocks have undergone significant declines in recruitment in Lake Huron over the past 10-20 years. These declines have been attributed to a reduction in the zooplankton prey available for larval life whitefish as a result of the ecosystem effects of dreissenid mussels. Here, we provide the results of a research study aimed at determining the extent to which declines in recruitment are linked to mechanisms and dynamics occurring at the larval fish stage. Larval fish surveys were conducted in 2017-2022 at the Fishing Islands spawning shoal complex, as well as several other spawning regions within Lake Huron. Historical surveys were also conducted at the Fishing Islands in 1976-1986, a time when population abundance was rapidly increasing and before the establishment of dreissenid mussels. We found an overall 75% reduction in the density and a 45% decline in the growth of larval lake whitefish at the Fishing Islands. Contemporary larval densities were also low in several other locations within Lake Huron. A positive relationship between larval density and later year class strength provides evidence that recruitment is being limited at the larval life stage.

**Peri Dworatzek**, Homa Hedayat, Dasha Litviniuc, Jess Ramsay and **Monika Sadler**, York University, Toronto, ON, Canada. **Human Use of an Ecological Wonder: Using Survey Data to Understand how People are Experiencing the Leslie Street Spit.**

As part of the Ruble to Refugee Project by the Toronto Region and Conservation Authority (TRCA) and York University, an online survey was completed to understand how users of the Leslie Street Spit experience the park. The survey asked park visitors many questions about their activities in the park and how it affects their experience with wildlife and nature. The survey was completed by over 400 participants, including quantitative and qualitative responses. Using this data, our team created several graphics and tables

to present the critical findings of the survey resulting in a 50 page report. These findings were examined regarding Tommy Thompson Park's (TTP) Master Plan to understand if the park is being used for its intended purpose. The main goal of TTP is to conserve and manage the natural resources and environmentally significant areas of the site by maintaining and improving wildlife habitat. The findings from the survey resulted in a deeper understanding of how humans are using the park. The results and key findings of this survey highlight the typical demographic of individuals who visit the park, the activities they do at TPP and the overall time spent at the park. This provides context and understanding for the TRCA when making decisions about care-taking of the wildlife and environment in the park.

# E

**Hamed Ebrahimi**[1], Leon Boegman[2], Reza Valipour[3] and Rohit Shukla[4], [1]Environmental Fluid Dynamics Laboratory, Department of Civil Engineering, Queen's University, Kingston, ON, Canada, [2]Queen's University, Kingston, ON, Canada, [3]Environment and Climate Change Canada, Burlington, ON, Canada, [4]Environmental Fluid Dynamics Laboratory, Department of Civil Engineering, Queen's University, Kingston, ON, Canada. **Automatic calibration of a three-dimensional hydrodynamic and water quality model using machine learning.**

Lake Erie has been negatively impacted by the cumulative effects of multiple stressors (e.g., nutrient enrichment, invasive species, and climate change). These have exacerbated the negative effects of harmful algal blooms and hypoxia. Simulations from coupled hydrodynamic-biogeochemical models can aid in the management of these water quality issues. However, these models remain poorly calibrated, due to the user and computational effort required to tune 100s of parameters, in comparison to years of monitoring data. The resulting uncertainties can lead to an inaccurate portrayal of coupled physical-biogeochemical processes. We propose using the XGBoost machine learning algorithm together with quasi-random Sobol sampling method to explore the parameter space and automatically calibrate the AEM3D-iWQ model for Lake Erie over 2017-2021, using the fewest possible model runs (compared to Bayesian or 'brute force' approaches).

**Thomas A. Edge**[1] and Joan B. Rose[2], [1]Department of Biology, McMaster University, Hamilton, ON, Canada, [2]Michigan State University, East Lansing, MI, USA. **Advancing molecular technologies and microbial water quality assessment in the Great Lakes basin.**

In 1913, an International Joint Commission (IJC) study by 17 labs in Canada and the U.S. used the most advanced microbiology methods of the time to identify sewage hotspots and the human health risks of untreated sewage releases into the Great Lakes. Since then, the scale and diversity of fecal pollution sources have changed, and new health risks like harmful algal blooms (HABs) have arisen. There have also been tremendous advances in molecular technologies to better assess microbial water quality, provide early warnings of health risks, and better understand the implications of changes to microbial communities (microbiomes). In 2022, the IJC convened 4 workshops with scientists and water policy experts to explore how, after 100 years, another large-scale Great Lakes Microbial Water Quality Study could advance and modernize microbial water quality assessment of health risks. The workshops identified molecular technologies for microbial source tracking, HABs assessment, and metagenomics analyses of microbial communities as applications ready to advance. Applications of quantitative and digital PCR were best documented for fecal pollution source identification by microbial source tracking, though lab capacity and active research using PCR and DNA/RNA sequencing was also identified throughout the Great Lakes basin for HABs assessment and metagenomics analyses. The IJC is seeking to develop a network of laboratories to further develop, validate, and harmonize application of molecular technologies across the Great Lakes basin.

**Emily J Edgley** and Aisha S Chiandet, Severn Sound Environmental Association, Port McNicoll, ON, Canada. **Citizen science in Severn Sound – assessing program success.**

The Severn Sound Environmental Association (SSEA) grew from being a Remedial Action Plan for Severn Sound, now a Delisted Area of Concern on the Great Lakes located in Southeastern Georgian Bay. Citizen engagement was critical in the delisting process and SSEA is focusing on strategies to re-engage residents. Having local eyes on the ground improves the capacity and reach for agencies engaged in environmental monitoring like SSEA. Citizen science programs in the Severn Sound watershed focus on lake and stream water quality, climate conditions, ice cover, invasive species, species at risk, and water level/high flow impacts. With proper training, quality control of data, and frequent communication, citizen science data provides valuable information, often at a finer temporal resolution and at sites not normally accessible for routine monitoring. Comparisons with data collected by the SSEA and government agencies indicate that volunteer data is generally of high quality and can be used to fill data gaps and dovetail with other monitoring programs, as well as identify priority areas for restoration. Furthermore, volunteers are empowered by contributing to increased understanding of conditions and issues in their area, making them more likely to become stewards of their local environment and share their knowledge with others.

**Elvita Eglite**[1], Anne E Scofield[1,2], Tomas O Hook[1,3] and Paris D Collingsworth[1,3], [1]Purdue University, West Lafayette, IN, USA, [2]US Environmental Protection Agency, Chicago, IL, USA, [3]Illinois-Indiana Sea Grant, West Lafayette, IN, USA. **Trophic dynamics of fishes in the Great Lakes: a cross-lake comparison using stable isotopes data.**

Stable isotope ratios of nitrogen ($\delta^{15}N$) and carbon ($\delta^{13}C$) are valuable tools for identifying basal energy sources for fish production and describing trophic complexity, but cross-lake comparisons are often limited by the challenges associated with standardizing study design and isotopic baselines. Using studies conducted in collaboration with the bi-national Cooperative Science and Monitoring Initiative, as well as other research efforts across the Great Lakes, we assembled $\delta^{15}N$ and $\delta^{13}C$ data for zooplankton and fish muscle tissue across all Great Lakes from 2002 to 2018. We aimed to detect differences in food web structures by estimating trophic positions (TP) and the ratio of benthic to pelagic $\delta^{13}C$ contributions for planktivorous Rainbow Smelt (*Osmerus mordax*) and piscivorous Lake Trout (*Salvelinus namaycush*). To account for variable baselines in the lower food web, we used averaged bulk zooplankton $\delta^{15}N$ values by lake, month, year. Despite high variation in the zooplankton, we identified a robust pattern in TP across lakes for both species. Consistent with predator-prey interactions, mean TPs of Lake Trout (4.1-5.9) were greater than Rainbow Smelt (3.1-4.6) in all lakes. TPs were lower in Superior, Huron and Michigan, and greater in Ontario and Erie. The proportion of benthic/pelagic contributions to fish diets also differed among lakes, with Lake Huron having the highest benthic reliance. Overall, TPs increased with the lake productivity and suggest that both food web complexity and resource use by these fish species differs across lakes.

**Armel Zacharie Ekoa Bessa**[1], Paul-Désiré Ndjigui[2] and Thierry Adatte[1], [1]ISTE, University of Lausanne, Lausanne, Switzerland, [2]University of Yaoundé 1, Yaoundé, Cameroon. **Lacustrine records from Cameroon lakes (SW-Africa): insight for paleoenvironmental evolution.**

Lacustrine sediments provide a historical record of the conditions of catchment environments. They are highly sensitive to paleoenvironmental change. The aim of this study is to reconstruct the paleoenvironment of 3 lakes located in Cameroon, SW-Africa, for the last 1000 years using a multiproxy approach including sedimentology, mineralogy, geochemistry, radiocarbon dating, diatoms and palynology. Sediment samples were taken from a raft and PVC pipes. They generally consist of sub-rounded and sometime rounded particles indicative of both aeolian and medium fluvial transport. The presence of quartz and clay minerals with rutile and calcite suggest high weathering under warm and humid conditions. These sediments derived from felsic, intermediate and mafic rocks from nearby granitic, gneissic and basaltic rocks. Weathering indices indicate high intensity of alteration related to both active and passive margin tectonism. Element ratios indicate a low compositional maturity in an oxic depositional condition and low

salinity paleoenvironment. These sediments were deposited in a shallow marine and fluvial depositional environments with an increase water depth environmental condition. Radiocarbon dating of the studied sediments are Holocene in age. Palynological and diatom data reveal major hydrological changes, which occurred over the last 1000 years, mainly characterized by strong fluctuations in wet and dry conditions during the "Medieval Warm Period" (1100-800 yrs BP) and dry conditions during the "Little Ice Age" (500-300 yrs BP).

**Eric Ellis**, Great Lakes Commission, Ann Arbor, MI, USA. **A review of nearshore breakwater projects for habitat improvement in the Great Lakes.**

The installation of detached breakwater structures, usually parallel to the shore, is frequently used to reduce wave energy in coastal systems of the Great Lakes. These constructed features can simulate natural features such as sandbars, reefs or islands and are often used to protect valuable coastal assets. Many recent projects have utilized small breakwater structures to create low energy environments with the intent of improving aquatic and coastal habitat, especially for fish and native vegetation. This presentation will review multiple case studies where nearshore breakwater structures have been installed, or are planned for installation, in lake and river systems to improve habitat. The review will include design and permit considerations, photo and video documentation of site conditions and construction activities, and results of pre and post construction monitoring efforts.

**Mariam Elmarsafy**, Kelly L Bowen, Heather A Niblock, Mark A.J. Fitzpatrick, Mohiuddin Munawar and Warren J.S. Currie, Fisheries and Oceans Canada, Burlington, ON, Canada. **Study of zooplankton communities in Area of Concern (Toronto Harbour).**

During monthly surveys of Toronto Harbour in 2016, Fisheries and Oceans Canada (DFO) Food-webs and Ecosystem Research determined that the inner harbour was impaired for phytoplankton and zooplankton populations based on finding very few large zooplankton and high rates of bacterial growth. However, the source of this impairment could not be identified, and this sampling was within the main inner harbour only. From 2018-2022 DFO returned to include important fish habitat restoration locations within the Toronto Islands and in Tommy Thompson Park (embayments and habitat cells). We find high annual and seasonal variability in community composition, but consistently find that zooplankton in the surrounding embayment's, Toronto Islands, and the habitats within Tommy Thompson Park have higher densities and more seasonal variability compared to the inner harbour. Physical water characteristics in the inner harbor such as temperature, turbidity and nutrient do change seasonally compared to the surrounding habitats, yet low zooplankton counts of particular species groups still persists. We will summarize the report assessing plankton populations and discuss implications for fish populations.

**Ahmed Elsayed**[1], Sarah Rixon[1], Jana Levison[1], Andrew Binns[1] and Pradeep Goel[2], [1]University of Guelph, Guelph, ON, Canada, [2]Ontario Ministry of the Environment, Conservation and Parks, Etobicoke, ON, Canada. **Application of machine learning algorithms in categorizing nutrient concentrations in an agricultural watershed.**

Agricultural areas are considered significant non-point sources of nutrient (e.g., nitrogen and phosphorus) release to surface water and groundwater due to the application of synthetic fertilizers and manure. This can deteriorate water quality, leading to critical environmental and public health problems. Thus, quantification and understanding of nutrient transport in water resources is essential. Machine learning (ML) algorithms can be implemented as an effective approach for better understanding nutrient transport processes in surface water and groundwater. ML algorithms can yield high performance for simulating the complexity of transport processes since they can diagnose the interdependence between the involved process variables where ML models deal with the input and output variables based on historical observations. In the current study, different families of classification ML algorithms (e.g., decision trees and

support vector machine) were implemented on a dataset of five observation sites in an agricultural watershed in southwestern Ontario (Upper Parkhill watershed; Lake Huron basin) in Canada to categorize the nutrient concentrations in surface water using a group of input variables. The input variables included the weather conditions (e.g., precipitation depth), water chemistry parameters (e.g., pH), hydrological (e.g., surface flow) and field (e.g., land use) conditions. The results of ML models can be used by decision makers to take effective measures to enhance groundwater and surface water quality in agricultural watersheds.

**Hector J Esparra-Escalera** and Donna R Kashian, Wayne State University, Detroit, MI, USA. **Land use effects on nutrient pollution and benthic macroinvertebrate assemblages in Michigan streams.**

Nutrient pollution in Great Lakes streams negatively impacts biota, water quality, and aquatic industries such as tourism and water treatment. We examined long-term median concentrations of nitrogen (N) and phosphorus (P) constituents, and relationships among land use and benthic macroinvertebrate diversity. Records between 2022-2021 for Michigan (USA) were retrieved from multiple agencies in the *Water Quality Portal*, synthesized, and partitioned by undeveloped, developed, and agricultural (>45% dominance), mixed (<45%), and percent of developed/agricultural land-cover (0-10%, 10-20%, 20-30%, 30-40%, >40%). Statewide, median concentrations of TN ranged between 0.53-1.44 mg/L, with no marked differences among land use, and TP ranged between 0.03-0.09 mg/L from developed/agricultural sites. The median concentrations of inorganic nitrogen and ammonia were two to ten times higher in developed/agricultural areas compared to undeveloped areas. Collector-gatherers were the dominant macroinvertebrates overall, but highly polluted sites had fewer collector-filterers and more predators. Identifying impaired streams could focus and improve management efforts and shed light on how macroinvertebrate composition and resilience play in nutrient cycling.

**Janessa Antonia Esquible**, University of Alaska Fairbanks, Bethel, AK, USA. **Salmon, Stewardship and Protecting Indigenous Livelihoods in Southwestern Alaska.**

This presentation uplifts Alaska native voices, stewardship practices, governance mechanisms and values pertaining to salmon in southwestern Alaska. This Indigenous-led research project conducted 28 semi-directed interviews with 46 Alaska Native fishers from the headwaters of the Kuskokwim River and down to Kuskokwim Bay, encompassing three distinct regions of the Kuskokwim River. This research embraces Indigenous knowledge systems, sovereignty, and governance structures, while also elevating critical concerns with salmon and fisheries management today, all of which pose threats to Indigenous livelihoods. This presentation highlights research conducted as a part of the Indigenizing Salmon Science and Management statewide project. The Indigenizing Salmon Science and Management project is centered on Indigenous cosmologies and methodologies to better understand the ways in which Alaska Native people stewarded salmon while incorporating values and providing ideas to improve current management practices and systems. This work begins to identify solutions and a path forward toward a more equitable salmon management system, and one that is grounded in Alaska Native stewardship practices and values.

**Kelly Evans** and Julian Aherne, Trent University, Peterborough, ON, Canada. **Road Dust as an Indicator of Microplastic Deposition in the Greater Toronto Area, Ontario.**

In southern Ontario, MP contamination has been widely reported in freshwater environments, including Great Lake Basins. However, few studies have assessed atmospheric MP deposition, particularly in urban environments. During summer 2022, we sampled road dust from paved surfaces in commercial and industrial areas throughout the Greater Toronto Area as an indicator of microplastic deposition. Road dust was sampled along a 10 m transect using a natural fiber brush and metal dustpan from 8 commercial and 8 industrial sites. MP were extracted from dust samples by density separation (water and sodium iodide) followed by vacuum filtration onto glass-fiber papers. MP were then visually identified using an optical stereomicroscope and polymer composition was determined using Fourier-Transfer Infrared spectroscopy.

Here, we report a comparison of MP characteristics, abundance, and polymer composition across sampling locations to assess the relative difference in microplastics between land uses. Keywords: plastic pollution; atmospheric deposition; source identification; Fourier-Transfer Infrared Spectroscopy.

**Mary Anne Evans**[1], Katarzyna Przybyla-Kelly[2], Megan Lewan[1], Shelby Eagan[1] and Madeleine Giordano[1], [1]United States Geological Survey, Ann Arbor, MI, USA, [2]USGS, Chesterton, IN, USA. **Nuisance algae growth conditions in Lakes Michigan, Huron, Erie, and Ontario.**

The benthic green algae *Cladophora* sp. and an associated community of benthic and epiphytic algae can create nuisance conditions through prolific growth, oxygen depletion, shoreline washup, and promotion of bacterial growth. In support of binational management efforts, we are assessing benthic algal growth and potential growth limiting factors at sentinel sites in Lakes Michigan, Huron, Erie, and Ontario. Recent efforts have focused on the past 5 years of nutrient (nitrogen and phosphorus) concentration data around benthic algal beds. Assessments of vertical nutrient distributions show patterns indicative of benthic nutrient sources or accumulation at sample sites in all four lakes. As expected, the benthic accumulation of nutrients is more common during quiescent conditions and is not seen when indicators or forcers of water mixing (near bottom water speed, wave height) exceed critical values. In contrast, less bioactive constituents (e.g., chloride) concentrations were only rarely elevated in bottom waters relative to near the surface. Results since 2018 are consistent with the growing scientific consensus that dreissenid mussels have altered the nearshore Great Lakes ecosystem in ways that promote benthic algal growth.

**Thomas M Evans**[1], Lars G. Rudstam[2], Suresh A. Sethi[1], Daniel L Yule[3], S Dale Hanson[4], Benjamin Turschak[5], David M Warner[6], Steven A Farha[6], Timothy P O'Brien[6], Kevin N McDonnell[7], James M Watkins[2], Mark R DuFour[6], Andrew R Barnard[8], Susan E Wells[4], Scott R Koproski[7], Patricia M Dieter[6], Erik Kocher[9], James J Roberts[10], Jason D Swain[11] and Peter C Esselman[6], [1]Cornell University, Ithaca, NY, USA, [2]Cornell Biological Field Station, Bridgeport, NY, USA, [3]U.S. Geological Survey, Lake Superior Biological Station, Ashland, WI, USA, [4]U.S. Fish and Wildlife Service, Green Bay Fish and Wildlife Conservation Office, New Franken, WI, USA, [5]Michigan Department of Natural Resources, Charlevoix Fisheries Research Station, Charlevoix, MI, USA, [6]U.S. Geological Survey, Great Lakes Science Center, Ann Arbor, MI, USA, [7]US Fish and Wildlife Service, Alpena Fish and Wildlife Conservation Office, Alpena, MI, USA, [8]Graduate Program in Acoustics, Penn State, State College, PA, USA, [9]Michigan Technological University, Department of Civil and Environmental Engineering, Houghton, MI, USA, [10]U.S. Geological Survey, Great Lakes Science Center,, Sandusky, OH, USA, [11]Michigan Technological University, Great Lakes Research Center, Houghton, MI, USA. **Assessing fish avoidance to motorized acoustic survey vessels using quiet autonomous Saildrones in the Great Lakes.**

Acoustic surveys provide opportunity to assess spatially extensive stocks and are widely used to evaluate prey fish throughout the Great Lakes. However, a major assumption of these surveys is that fish do not avoid vessels. Fish avoidance may result from a response to boat engine noise and can ultimately bias acoustic estimates of survey biomass. Thus, a greater understanding of avoidance behavior is necessary to evaluate the accuracy of acoustic surveys. To address this gap, we used quiet uncrewed surface vehicles (Saildrone) to test potential fish responses to conventional motorized survey ships on the Great Lakes. The Great Lakes provide an ideal region to test for fish avoidance because surveys are conducted by numerous vessels on differing fish communities. Autonomous Saildrones were equipped with a 120 kHz Simrad EK80 transducer and deployed in Lakes Huron and Michigan in the summer of 2021, and Lake Superior in the summer of 2022. Saildrones were overtaken by eight different motorized survey vessels to facilitate acoustic signal and fish response comparisons between noisy and quiet platforms. We compared the differences in average target depth, target strength, and acoustic back-scattering over 2km transects surveyed by both Saildrone and motorized vessels. We also tested for a fish behavioral response signal by fitting regression smoothers to Saildrone acoustic data as motorized vessels approached. This work informs interpretation of

acoustic data in the Great Lakes and provides the largest scale testing of fish avoidance to acoustic surveys to date.

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**Mona Farhani**, Alice Grgicak-Mannion, Paul Weidman and Ken G Drouillard, Great Lakes Institute for Environmental Research, University of Windsor, Windsor, ON, Canada. **Artificial neural network modeling of sediment organic carbon, and PCBs in the Detroit River.**

To study the highly complex structure and dynamics of ecological systems, powerful tools must be applied, such as Artificial Neural Networks (ANNs), which are very effective at dealing with non-linear relationships. The purpose of this study is to develop predictive models to interpolate sediment polychlorinated biphenyls (PCBs) and total organic carbon (TOC) throughout the Detroit River area of concern (AOC) and generate high resolution distribution maps to inform planned restoration activities. A multilayer perceptron (MLP) ANN with an error backpropagation algorithm model was used to estimate PCB and TOC concentrations based on site specifications and chemical characteristics. However, black box models like ANNs lack insight into the contributions of independent variables in process models. A statistical weighting method was implemented to determine the influence of each input variable and its contribution to the model outcome. The result showed that the $R^2$ of the model for TOC model was near 60 percent. Site specification physical characteristics were calculated using the Arc Pro GIS. **Key words:** Contaminated sediments, Detroit River, Hazard assessment, Neural network model

**Christopher Robert Farrow**[1], Josef D. Ackerman[1] and Loong-Tak Lim[2], [1]Department of Integrative Biology, University of Guelph, Guelph, ON, Canada, [2]Department of Food Science, University of Guelph, Guelph, ON, Canada. **Physical modelling of dispersal in Grand River watershed tributaries with different hydrodynamic conditions.**

The dispersal of live propagules is often modeled through the release of non-biodegradable plastics and other materials. We modeled the dispersal of juvenile freshwater mussels (Unionidae) in the field using novel coloured biodegradable and non-toxic microbeads ($D \sim 250$ μm; $\varrho \sim 1200$ kg $m^{-3}$). We released the microbeads at three sites in the Grand River watershed [Speed River (n = 36), Grand River (n = 26), Conestogo River (n = 27)] in which high-resolution riverbed elevation surveys and Acoustic Doppler Velocimetry indicated gradients of substrate roughness and turbulence among the sites [Speed ($U = 9.5 \pm 0.01$ cm $s^{-1}$) < Grand ($17.8 \pm 0.01$ cm $s^{-1}$) < Conestogo ($19.9 \pm 0.03$ cm $s^{-1}$)]. Roughness heights and median grain size ($d_{50}$) along particle release transects followed a similar pattern: 3.6 cm and 5.2 cm in the Speed; 5.1 cm and 6.3 cm in the Grand; and 6.9 cm and 7.3 cm in the Conestogo. Not surprisingly, turbulent kinetic energy at 50% water depth was $(1.9 \pm 0.4) \times 10^{-3}$ $m^2$ $s^{-2}$ in the Speed, $(4.4 \pm 0.6) \times 10^{-3}$ $m^2$ $s^{-2}$ in the Grand, and $(1.2 \pm 0.2) \times 10^{-2}$ $m^2$ $s^{-2}$ in the Conestogo. In contrast to the roughness and turbulence gradients among rivers, microbead flux in drift nets declined most rapidly with downstream distance at the Grand ($-0.1 \pm 0.01$ microbeads $m^{-3}$ $s^{-1}$), followed by the Speed (slope = $-0.08 \pm 0.01$ microbeads $m^{-3}$ $s^{-1}$), and Conestogo ($-0.06 \pm 0.01$ microbeads $m^{-3}$ $s^{-1}$). These findings suggest that turbulence and substrate roughness at small spatial scales (i.e., < 50 m) may enhance dispersal distances in rivers but more direct field measurements of particle flux to the riverbed are needed.

**Catherine Febria**[1] and Clint Jacobs[2], [1]University of Windsor, Windsor, ON, Canada, [2]Walpole Island Heritage Centre, Walpole Island First Nation, Bkejwanong, ON, Canada. **Nurturing transformative change and reconciliation pathways: A case study of Canada's National Urban Parks Program.**

A presentation on a partnership-based, Indigenous-led approach to implementing Canada's National Urban Parks program using Windsor's Ojibway Prairie Complex as the case study.

**Abigail Fee**[1], Shelley Arnott[1], Troy Martin[1] and Lisa Cicchetti[2], [1]Biology, Queen's University, Kingston, ON, Canada, [2]Queen's University, Kingston, ON, Canada. **Assessing the toxicity of a beet-juice brine de-icing product to *Daphnia pulicaria*.**

There is increasing concern over rising salinity in freshwater ecosystems associated with increasing road density and salt usage. Negative environmental impacts of road salt include changes to aquatic community composition and loss of biodiversity. Consequently, municipalities have started using alternative de-icers marketed as 'eco-friendly'. One example of an organic alternative is beet-brine which contains degraded beet sugar and chloride salts. There is limited research on the effects of these products on aquatic organisms, and the effects on zooplankton have rarely been tested. Zooplankton are important to test as they feed higher trophic levels and control algae levels. To address this research gap, I tested the acute toxicities of a beet-juice brine product (Fusion 2330™) and KCl (>99% pure), a component of beet juice, to *Daphnia pulicaria* using 48hr $LC_{50}$ tests. We found that *D. pulicaria* were more tolerant to KCl than Fusion 2330™ with $LC_{50}$ values of 96 mg Cl-/L for Fusion 2330 and 267 mg Cl-/L for KCl. For comparison, the $LC_{50}$ of NaCl with the same iso-female line of *D. pulicaria* was 1810 mg Cl-/L. These results suggest that beet-brine may be more toxic to aquatic organisms than commonly used rock salt. However, low dissolved oxygen concentrations in the beet-brine treatments indicate that oxygen depletion by microbial respiration may be a large cause of the product's toxicity. Future studies should examine if beet-juice brine is modified in natural environments and if oxygen depletion occurs in soil or water due to the addition of organic de-icer alternatives.

**Mohammad Fereshtehpour**[1], Mohammad Reza Najafi[2] and Alex J. Cannon[3], [1]Postdoctoral Associate, Department of Civil and Environmental Engineering, Western University, London, ON, Canada, [2]Associate Professor, Department of Civil and Environmental Engineering, Western University, London, ON, Canada, [3]Climate Research Division, Environment and Climate Change Canada, Victoria, BC, Canada.
**Characterizing Compound Inland Flooding in the Great Lakes Region under Climate Change.**

The Great Lakes region is experiencing considerable challenges associated with climate change. Development of effective mitigation and adaptation measures, including improved adaptive management of the Great Lakes, requires the identification and characterization of the nonstationary hydroclimate extremes. Compound Inland floods, which are triggered by the interplay of two or more hydrometeorological factors, can cause catastrophic societal and environmental repercussions. In this study, we analyze three principal types of inland compound flooding occurrences in the Great Lakes region: rain-on-snow (ROS), saturation excess flooding (SEF), and a temporally compounding event represented by a series of precipitation (SOP) occurrences. The assessments are based on the 50-member CanRCM4 large ensemble simulations for the baseline period of 1986 to 2016 and three 31-year periods that correspond to warming levels of 2, 3, and 4°C above preindustrial levels. We further examine the role of internal climate variability in inland compound floods using the large ensemble distribution. Overall, the results indicate a rise in SOP events and a reduction in ROS events, as the primary mechanisms of compound flooding, in the future. In addition, SEF and SOP occurrences show a more pronounced uncertainty associated with internal climate variability compared to ROS events in a warmer climate. Characterizing the future regional compound flood-generating processes in the Great Lakes region can lead to robust flood risk assessment and effective mitigation strategies.

**Daniel Ferreira**, Environment and Climate Change Canada, Burlington, ON, Canada. **Identifying Lake Ontario shoreline vulnerabilities to extreme water level conditions.**

In 2017, the International Joint Committee (IJC) implemented Plan 2014 for the regulation of outflows from Lake Ontario into the St. Lawrence River. The plan was designed to protect stakeholders, improve ecosystem outcomes and perform better in changing climate conditions. Plan 2014 is to be reviewed through an adaptive management process and the IJC tasked its Great Lakes-St. Lawrence River Adaptive Management (GLAM) Committee to undertake the monitoring, modelling and assessment to

support the ongoing evaluation. Extreme water supply conditions in 2017 and 2019 led to record high water levels on Lake Ontario – St. Lawrence River and extensive damage to shoreline property. The GLAM Committee acquired shoreline impact data from various sources including property owners directly through questionnaires, outreach efforts with the public and municipal officers, site visits and imagery interpretation from these flood events. The impact data revealed a wide range of vulnerabilities to high water levels and the need to develop new or improved shoreline performance indicators that can be used to support the Plan 2014 evaluation process. The GLAM Committee is moving forward with indicator updates using the new information which will allow for improved future modelling of shoreline impacts for Plan 2014 and a range of alternatives.

**Brick Fevold**[1], Tim Lewis[1], Cynthia Collier[1], Craig Palmer[1], Molly Middlebrook[1] and Louis J. Blume[2], [1]GDIT, Falls Church, VA, USA, [2]EPA Region 5, Chicago, IL, USA. **Designing Ecological Restoration Goals and Objectives to be Climate Smart.**

Assessment of project vulnerabilities and risks to climate change is an important component to the development of project goals and objectives – and vital to demonstrate that project outputs and outcomes are 'climate-smart.' A lack of accounting for regional effects of climate change can lead to generating unreliable outputs (e.g., datasets, budgets, design plans) and reduced confidence in achieving restoration outcomes (e.g., reduction in phosphorus loading). Fortunately, guidance by EPA and other institutions on climate change adaptation planning, resources provided by the U.S. Climate Change Toolkit and the Northern Institute of Applied Climate Science, and a suite of other tools are available to support decision makers involved in restoration planning and design. Reflecting on these resources, we describe four steps that planners can take to incorporate climate risks into planning and design in ecological restoration. These include: 1) assess the problem and need for restoration in context of changing climate patterns, 2) define realistic goals and SMART objectives that account for climate change uncertainty, 3) plan for evaluation and adjustment or adaptation, and 4) develop a structured framework for effective decision-making. This work is funded under EPA contract in support of the Great Lakes Restoration Initiative.

**Deanna Fielder**[1], Jamie Ferguson[2], Yin Fan[3] and Matthew McClerren[1], [1]U.S. Army Corps of Engineers Detroit District, Detroit, MI, USA, [2]Environment and Climate Change Canada, Cornwall, ON, Canada, [3]National Hydrologic Service, ECCC, Cornwall, ON, Canada. **Hydroclimate Baseline Datasets for Great Lakes Adaptive Management.**

Water management in the Great Lakes region requires development of consistent datasets. Coordination of these datasets is necessary due to the shared water resources between the United States and Canada. The United States Army Corps of Engineers (USACE) and Environment and Climate Change Canada (ECCC) are tasked with creating and maintaining datasets that can be used by federal agencies when conducting water management activities. This is particularly important for testing and developing regulation plans at two points in the system where outflows are regulated. Outflow regulation occurs at the St. Marys River, which connects Lake Superior with Lake Michigan-Huron, and at the St. Lawrence River, which is the outflow from Lake Ontario. In the recent years of record high water levels, the Great Lakes – St. Lawrence Adaptive Management (GLAM) Committee has been tasked with doing an expedited review of the current regulation plan (Plan 2014) for Lake Ontario and the St. Lawrence River System. In this effort, USACE and ECCC have been delegated with coordinating data and supplying the project team with baseline datasets, as well as metadata. These baseline datasets are critical for further analyses to be conducted by the GLAM committee. Datasets include water levels, flows through the connecting channels, diversion flows, and net basin supply.

**Alex Justin Fields**[1], Tomas O Hook[2] and Paris D Collingsworth[2], [1]Purdue University, West Lafayette, USA, [2]Illinois-Indiana Sea Grant, West Lafayette, IN, USA. **Spatially and temporally heterogeneous trends in surface chlorophyll-a in Lake Superior from 2014-2018.**

Historically, Lake Superior is the least productive of all the Laurentian Great Lakes. Due to a warming climate, Lake Superior is now one of the most rapidly warming lakes on the planet and there is a growing need to track changes in the lake's seasonal productivity patterns, as indicated by increasing reports of transient harmful algae blooms in nearshore areas of the lake. Long term, lake-wide water quality surveys are conducted regularly in Lake Superior, but methods that can further increase the resolution of water quality monitoring are welcome. This study uses a 5-year dataset of satellite-derived monthly estimates of lake-wide surface chlorophyll-a concentrations (a proxy for primary production) observations using a band-ratio retrieval algorithm. Our objectives were to assess spatiotemporal patterns of surface chlorophyll-a by considering a) annual and seasonal variation, b) spatial variation among different regions of the lake and c) variation by depth strata. We found that surface chlorophyll-a was consistently higher in the western region of Lake Superior. Finally, when chlorophyll-a concentrations were characterized based on distance from the shoreline, chlorophyll-a concentrations were highest in the nearshore and decreased with distance from shore. Contrasting temporal and spatial trends in surface chlorophyll-a across different regions of the lake have important implications for water quality and fisheries management in Lake Superior and this study provides a method for quantifying long-term changes in Lake Superior's productivity.

**Lindsay Fitzpatrick**[1], Dan Titze[2], Dmitry Beletsky[3], Eric J Anderson[4] and John G. W. Kelley[5], [1]Cooperative Institute for Great Lakes Research, Ann Arbor, MI, USA, [2]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, USA, [3]School for Environment and Sustainability, University of Michigan, Ann Arbor, MI, USA, [4]Colorado School of Mines, Golden, CO, USA, [5]NOAA National Ocean Service, Silver Spring, MD, USA. **Improving Flood Forecast Guidance for Ports in the Great Lakes Using a Linked Hydrologic-Hydrodynamic Framework.**

The NOAA Great Lakes Operational Forecast System (GLOFS), based on the Finite-Volume Community Ocean Model (FVCOM), provides water forecast guidance across the Great Lakes, however, it does not include harbors and navigational ports. While GLOFS does include inflow from some gauged streams, large volumes of water entering the lakes through tributaries are not being accounted for. To examine the benefits of including model coverage over marine infrastructures, a linked hydrologic-hydrodynamic framework was developed for the Twin Ports of Duluth-Superior in western Lake Superior. Simulated streamflow from the National Water Model (NWM) was injected into an extended wet-dry FVCOM grid that covered the harbor and surrounding floodplain. Test cases were conducted for severe flooding events caused by heavy rainfall and/or storm surges to see if the one-way coupled models could capture coastal flooding. Model results compared well against time-series of water level, with root mean square error (RMSE) and bias values small relative to the typical fluctuations. Inclusion of streamflow for NWM-simulated tributaries improved the accuracy of modeled water levels in the harbor and increased simulated current speeds in navigational channels by up to 0.4 ms-1. Modeled inundation and flood extent in the floodplain closely matched surveys conducted in response to a record flood event in 2012. The results demonstrate the capability of the modeling framework to provide flood guidance in a complex coastal setting in the Great Lakes region.

**Mark A.J. Fitzpatrick**, Mohiuddin Munawar, Heather A Niblock, Kelly L Bowen and Warren J.S. Currie, Fisheries and Oceans Canada, Burlington, ON, Canada. **Putting algal blooms under the microscope: A planktonic food web perspective on algal blooms in the Great Lakes.**

Concerted efforts have been made to reduce the occurrence and frequency of algal blooms in the Great Lakes via phosphorus abatement. Despite this, blooms remain common in shallow, nutrient enriched nearshore habitats. From a food web perspective, algal blooms are complex ecological entities that include autotrophs (phytoplankton, picoplankton) and heterotrophs (bacteria, nanoflagellates, ciliates, rotifers,

zooplankton). Our research and monitoring programs have captured a variety of blooms (Cyanobacteria, diatoms etc) from the Bay of Quinte and Hamilton Harbour in Lake Ontario as well as from western Lake Erie. The contribution of heterotrophs during bloom events can be similar to or even larger than that of phytoplankton. In the Bay of Quinte (2018), for example, heterotrophs accounted for 38 – 63% of the total planktonic biomass during bloom events with varying contributions from bacteria (17 – 22%), heterotrophic nanoflagellates (4 – 38%) and zooplankton (2 – 20%). Preliminary results suggest that all types of algal blooms, not just ones exhibiting toxicity, can have a significant ecological impact. The current paper will explore the taxonomic structure of the phytoplankton community during bloom events and consider the heterotrophic contributions in order to promote a better understanding of the ecological implications of algal blooms.

**Hugo Flávio**, Milica Koledin, Leonard D'Souza and Michael P Wilkie, Wilfrid Laurier University, Waterloo, ON, Canada. **The effect of Acclimation Temperature and TFM Concentration on the Oxygen Consumption of Larval Sea Lamprey.**

Sea lamprey (*Petromyzon marinus*) invaded the Laurentian Great Lakes in the early 20$^{th}$ century, and remain troublesome pests that pose a threat to fisheries. Being an non-homing ancient species with a wide native range, sea lamprey larvae can face a wide range of environmental conditions. Particularly, we are interested in the thermal tolerance of sea lamprey, as recent developments show that the larvae become more tolerant to the lampricide 3-trifluoromethyl-4'-nitrophenol (TFM) as temperatures increase. Here, we build upon our earlier intermittent-respirometry results, which revealed the larvae sea lamprey thermal performance curve, by taking into consideration the effects of different acclimation temperatures. We also evaluate the effects of a gradient of TFM concentrations on the oxygen consumption ($\dot{M}_{O2}$) of resting larvae, revealing a gradual increase in $\dot{M}_{O2}$ as TFM concentration increases. This is consistent with the TFM's mode of action, and reinforces the link between a higher aerobic scope and a higher resistance to the lampricide.

**Shane Flinn**[1] and Kelly Filer Robinson[2], [1]Michigan State University, East Lansing, MI, USA, [2]U.S. Geological Survey, Georgia Cooperative Fish and Wildlife Research Unit, Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA, USA. **The consequences of connectivity: A decision analytic approach to fish passage decisions.**

Barrier removal and remediation restores physical stream processes and improves accessibility of critical habitats to migratory fishes. Although increasing connectivity is beneficial to stream systems and migratory fishes, barrier removal and remediation decisions can lead to tradeoffs between the benefits to desirable species and the potential increased production of undesirable and invasive species, alongside a myriad of other ecological, social, and economic concerns stakeholders may have. This research uses Structured Decision Making to evaluate the ecological, social, and economic consequences and tradeoffs of enhancing connectivity for migratory fishes in the Great Lakes basin, using the Boardman (Ottoway) River FishPass project as a case study. Individual-based models were developed to estimate the consequences of possible management alternatives by predicting production of six species under five stakeholder-defined fish passage scenarios. Population response to barrier removal was species-specific and varied based on initial population size and distribution within the watershed, the number of fish passed upstream, and species life history traits. Our results will help inform decision-makers on management alternatives for fish passage on the Boardman River that are ecologically and socially acceptable to stakeholders and that are likely to achieve their objectives. This decision framework and associated models could be modified for other systems in which changes to connectivity are being considered.

**Jersey Allyson Fontz** and Rebecca Rooney, University of Waterloo, Waterloo, ON, Canada. **Leveraging priority effects to resist biological invasion: Marsh organs.**

Biodiversity in wetlands is threatened due to the invasion of non-native plants such as *Phragmites australis*. There has been successful *P. australis* suppression in Long Point, Ontario wetlands. These areas recovered vegetation passively – restoration post-herbicide suppression relied on the seed bank or propagule spread from nearby sites to revegetate a treated area. Initial recovery was delayed by secondary invasions from non-native species. One of the reasons that passive restoration failed to support immediate recovery by native vegetation is that native species propagule density is insufficient compared to non-native species propagule density. In these cases, active restoration may support the recovery of diverse plant communities by supplementing native propagule sources and by harnessing priority effects to give native species a competitive advantage. My objective was to test whether active seeding of treated marsh would improve restoration outcomes after *P. australis* suppression. I tested the effect of seed mix diversity and seeding density on measures of restoration success: floristic quality, abundance and richness of native vs. non-native species, and plant standing crop biomass. I used a marsh organ to simulate lower water levels, as Lake Erie water levels are projected to continue to drop. The results of my work will help develop restoration seed prescriptions that will maximize biotic resistance to invasive wetland plants, safeguarding our investments in invasive plant management and promoting successful recovery of native plants.

**Gregary Ford**, Niagara Coastal Community Collaborative, Niagara-on-the-Lake, ON, Canada.
**Crowdsourcing coastal information and improving decisions with the Visual Assessment Survey Tool.**

Changes are occurring across our Great Lakes at an increasingly accelerated rate and at a more magnified scale than previously recorded. Facing extreme weather, coastal communities are those first and most impacted. The Visual Assessment Survey Tool (VAST) is a collaborative initiative created by Niagara Coastal in partnership with the Niagara Peninsula Conservation Authority and Niagara College to substantiate the shifting trends of the Great Lakes' shorelines with evidence. VAST engages coastal citizens, community groups and other organizations in collecting observations and data to fill knowledge gaps and compliment water quality monitoring data for Great Lakes shorelines. Community involvement through citizen science fosters a deeper connection to the coast and improves coastal literacy by engaging participants in routine monitoring. Citizen scientists complete surveys and submit standardized photos to record changes to the coasts over time. Repeat VAST submissions create a near real-time repository of coastal conditions, enhancing decision-making for coastal residents and managers.

**Caitlin Fortune**[1], David Lawrie[1] and Jonathan Ruppert[2,3], [1]Toronto and Region Conservation Authority (TRCA), Vaughan, ON, Canada, [2]Toronto and Region Conservation Authority, Vaughan, ON, Canada, [3]Department of Ecology and Evolutionary Biology, University of Toronto, Toronto, ON, Canada.
**Monitoring movement of Redside Dace and congener species to identify overwinter habitat and inform recovery plans.**

Redside Dace (Clinostomus elongatus) are an endangered species, provincially and federally, that are experiencing rapid population decline in Canada. While spawning and summer habitat use is relatively well-defined, overwinter habitat requirements remain a gap in the knowledge needed to help support conservation efforts. This study employed a tag-recapture approach to track the location and timing of movement during the winter season for several fish species using Passive Integrated Transponder (PIT) tags. In addition to Redside Dace, congener species, Creek Chub (Semotilus atromaculatus), Common Shiner (Luxilus cornutus), and Blacknose Dace (Rhinichthys atratulus) were tagged over a two-year study period. The identification of potential overwinter habitat and tagged fish presence were confirmed using a combination of a series of cord and submersible arrays, and active tracking with a PIT tag reader accompanied by underwater camera filming. Environmental data (e.g., depth, flow, sediment type) and landscape data related to habitat conditions were also gathered to characterize overwinter habitat conditions.

Preliminary results find clustering of species within the study site, as well as general habitat characteristics where these species are found over the winter period. Together these new data have provided us with a better understanding of the movement and habitat usage of these species within the study area, which can contribute to future recovery planning.

**Sam Francis**[1], Michael Brooker[1], Nathan Stoltzfus[1], Chad Penn[2] and Jay Martin[1], [1]The Ohio State University, Columbus, OH, USA, [2]United States Department of Agriculture Agricultural Research Service, West Lafayette, IN, USA. **Combating Legacy Phosphorus: Phosphorus Removal Structures for Tile-Drained Agricultural Fields.**

Agricultural "legacy" phosphorus (P) reserves act as long-term sources of bioavailable dissolved P (DP), providing the limiting nutrient for harmful algal blooms in freshwater systems like Lake Erie. To address legacy sources, phosphorus removal structures (PRS) are a best management practice designed to provide a P-sorbing buffer between agricultural production and surface water flows. While PRSs have been shown to reduce P from surface runoff, capturing about 30% of non-point source DP, this technology is not well tested for tile-drain P loss. Further, data indicate susceptibility to physical clogging. Therefore, this study evaluates two in-field PRSs with novel P-sorbing media (PSM) to determine their ability to reduce DP over their lifetime and their economic efficacy. Preliminary findings indicate that over a year-long period, the PRS with an iron-PSM reduced the average DP concentration from 0.28 mg/L to 0.15 mg/L, and removed 49% of the dissolved P load. Meanwhile, a PRS with an aluminum-PSM reduced the inflow concentration from 1.06 to 0.06 mg P/L, and removed 92% of the load that entered the PRS. However, when water that bypassed the PRS due to clogging is included in this calculation, removal decreased to 44%. Thus, while PRSs have potential for mitigating P losses from legacy P fields, they can be limited by clogging. To reduce uncertainty about clogging, PSMs should be tested at the lab- or pilot-scale using tile-drainage water before being employed at the field-scale.

**Gail Fraser**[1], Andrea Chreston[2], Karen McDonald[2], Louisa Gentile[1] and Ralph Toninger[2], [1]Faculty of Environmental and Urban Change, York University, Toronto, ON, Canada, [2]Toronto and Region Conservation Authority, Vaughan, ON, Canada. **Loss of a species: Black-crowned night-herons at Tommy Thompson Park.**

Black-crowned night-herons started nesting in trees at Tommy Thompson Park (TTP) in 1980 (n=42 nests). Nest numbers fluctuated over the years peaking in 2000 (n=1235). In 2022, night-herons did not nest at TTP for the first time in 42 years. From 2011 to 2021, we measured nest success, number of chicks fledged, and tried to identify causes of nest failure. Between 2011 – 2016 average annual nest success ranged from 8% to 77% (n = 426 nests). There was complete nest failure in the last 4 study years (n = 91 nests). For 5 years (2011, 2015, 2016, 2017) we used a treatment (T)-control (C) approach using sheets of metal wrapped around tree trunks to deter raccoon predation. The experiment showed that the treatment was not independent of nest success ($p < 0.001$; 81 T and 34 C nests succeeded; 86 T and 105 C nests failed). In 2 out of 6 years using predator guards, raccoons caused 58% and 77% of nests lost in control trees and likely caused all nest failure prior to site abandonment. While predator guards were somewhat successful at reducing nest failure, it is a burdensome management option. Given TTP's urban wilderness status, raccoon control is unlikely. Colonial waterbird nesting locations are dynamic, but the complete loss of a species at TTP may modify the local ecology.

**Gail Fraser** and Jamian Rush, Faculty of Environmental and Urban Change, York University, Toronto, ON, Canada. **Occupancy and species diversity of carnivores at Tommy Thompson Park in relationship to nesting colonial waterbirds.**

Colonial nesting waterbirds can be heavily impacted by mammalian predators such as raccoons when present. For 8 years we deployed trail cameras at three stations on Peninsula C, Tommy Thompson

Park. Cameras, separated 500 m apart, were used when colonial waterbirds (tree-nesting double-crested cormorants and black-crowned night-herons) were present (May/June) and absent (September/October). We calculated percent occupancy for each carnivore species and Shannon-Wiener diversity index annually by season. Out of 1060 images, raccoons had the highest rate of capture (830 images), followed by coyotes (161), opossum (56), skunk (7), mink (5), and fox (1). Raccoon occupancy and number of captures had no difference among stations or season across eight study years. While coyote occupancy was more variable than raccoons, there was no trend for station or season. Species diversity was higher in the fall (average ± SD, 0.78 ± 0.3) compared to the spring (0.51 ± 0.1). Carnivore abundance, and possibly diversity, is likely supported by the seasonal presence of colonial waterbirds as prey, but more work is needed to understand these relationships at TTP.

**Brenna Friday**, Matthew Bossuyt and Donna R Kashian, Wayne State University, Detroit, MI, USA.
**Threat of toxic cyanobacterial blooms to early developing green frogs.**

Adverse effects of cyanotoxins to humans, fish and aquatic macroinvertebrates are well documented. However, few studies have examined the effects of cyanotoxins on amphibians potentially vulnerable species in Great Lakes coastal marshes. To address this gap, I designed a series of laboratory microcystin-LR (MCLR) exposure experiments measuring hatch success, growth, and survival from green frogs (*Rana clamitans*) eggs collected from the wild. In the first experiment, eggs were randomly assigned in groups of six (n = 35) to seven treatments containing 0-100 µg MCLR/L and monitored daily until hatch. In a second experiment, hatched tadpoles exposed to MCLR as eggs (n = 130) were individually randomly assigned treatments of one of six MCLR concentrations and monitored for changes in growth and survival for 18 days. Across both experiments, hatch success (97%) and tadpole survivorship (99%) did not differ among treatments. In secondarily exposed tadpoles, we found that total length and hind limb bud length were greatest in the toxin exposed groups ($p<0.05$). The apparent accelerated rate of development of embryonic and larval *R. clamitans* suggests high levels of physiological stress, which may implicate harmful algae blooms as another threat to already struggling amphibian populations in Great Lakes coastal marshes.

**Lauren M Fry**[1], Deanna Fielder[2] and Frank Seglenieks[3], [1]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, USA, [2]U.S. Army Corps of Engineers Detroit District, Detroit, MI, USA, [3]National Hydrological Service, ECCC, Burlington, ON, Canada. **Applications of Hydroclimate Data and Models in Adaptive Management of Great Lakes Outflows.**

Hydroclimate data provides the foundation of the adaptive management framework that guides the Great Lakes – St. Lawrence River Adaptive Management Committee's (GLAM) workflow. This workflow incorporates evaluation and continued monitoring of regulation plan performance under a variety of hydroclimate conditions in order to provide decision support to the International Joint Commission and its Boards of Control. The specific approach to providing information on hydroclimate conditions depends on the adaptive management application. For example, plan formulation and evaluation requires testing plans under a full range of plausible hydroclimate conditions. Whereas monitoring for changing hydroclimate conditions that may result in changes to plan performance requires observable indicators of hydroclimate regime change that may be determined through process-based and data-driven modeling. Projections of future conditions on scales ranging from subseasonal to decadal also provide useful information to aid in decision making. We will present recent and ongoing progress made (and gaps identified) by GLAM and its partners to advance hydroclimate data and modeling in consideration of the aforementioned applications.

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**Journ Galvan**[1], **Joshua Habib**[1], Raisa Beletsky[1,2] and Dmitry Beletsky[1,2], [1]School for Environment and Sustainability, University of Michigan, Ann Arbor, MI, USA, [2]Cooperative Institute for Great Lakes Research, University of Michigan, Ann Arbor, MI, USA. **Total bottom stress as a potential predictor of Microcystis resuspension in the western basin of Lake Erie.**

Previous studies have shown that the western basin of Lake Erie is prone to sediment resuspension due to its shallow depth and abundance of fine-grained sediments. Harmful algal blooms (HABs) caused by the bacteria *Microcystis* are also common in the western basin and have been shown to overwinter in the sediment layer. Total bottom stress combines shear stress caused by both waves and currents and is the most crucial factor influencing sediment resuspension. Our study utilized hindcasts of hydrodynamic models, specifically WAVEWATCH III (WW3) and Finite Volume Community Ocean Model (FVCOM), to calculate total bottom stress in the western basin of Lake Erie in May-October, 2017-2019. Results showed that wave-induced bottom stress dominated in the western basin, while current-induced bottom stress was smaller but could still cause resuspension during peak events. The highest total bottom stress values were associated with shallow waters (less than 5 m), which included the Maumee Bay and Detroit River mouth. Total bottom stress also varied seasonally, with the most significant values occurring in May and September-October and across years (2019 was less energetic than 2017 and 2018). Future work for this study will seek to identify resuspension events when total bottom stress exceeds the critical shear stress to move the sediment. Calculated bottom stress from WW3 and FVCOM models will also be tested as a potential predictor in retrospective statistical modeling to improve current HAB forecasts in Lake Erie.

**Yunpeng Gao**[1], James W. Roy[1,2] and Clare E. Robinson[1], [1]Department of Civil and Environmental Engineering, Western University, London, ON, Canada, [2]Water Science and Technology Directorate, Environment and Climate Change Canada, Burlington, ON, Canada. **Remote sensing tool to identify locations of septic systems within the Canadian Lake Erie Basin.**

Septic systems are commonly used for domestic wastewater treatment across the Great Lakes Basin in areas not serviced by a centralized wastewater treatment plant. These systems may be an important source of nutrients, including phosphorus (P) and nitrogen (N), to surface waters. Quantifying nutrient loads from septic systems is challenging because there is often no formal inventory of the numbers and locations of septic systems. While it has been previously estimated that there are approximately 130,000 septic systems across the Canadian Lake Erie Basin, there is a need to refine this overall estimate as well as develop an improved geospatial methodology to identify septic system locations based on available geospatial data. This study uses Digital Surface Model (DSM) and Digital Terrain Model (DTM) data from 2017 to 2018, with guidance from high-resolution aerial images to identify individual households that are likely to have a septic system. NDVI (Normalized Difference Vegetation Index) is calculated from the aerial images to distinguish trees and buildings and Texture Standard Deviation is used to reduce overestimating septic system numbers (i.e., due to vegetation identified as buildings). The geospatial tool was tested in several areas (10 $km^2$) with varying residential densities, and showed high accuracy of septic system placement. This new geospatial placement tool is needed as a first step for improving estimates of the contribution of septic systems to nutrient loads across the Canadian Lake Erie Basin.

**Spencer T Gardner**[1], Mark D. Rowe[2], Pengfei Xue[3], Xing Zhou[3], Peter J Alsip[4], David B. Bunnell[5], Paris D Collingsworth[6], Edward Rutherford[2] and Tomas O Hook[6], [1]Purdue University, West Lafayette, IN, USA, [2]NOAA GLERL, Ann Arbor, MI, USA, [3]Michigan Technological University, Houghton, MI, USA, [4]Cooperative Institute for Great Lakes Research, University of Michigan, Ann Arbor, MI, USA, [5]USGS Great Lakes Science Center, Ann Arbor, MI, USA, [6]Illinois-Indiana Sea Grant, West Lafayette, IN, USA. **The phenology of larval fish transport in Lake Michigan, USA.**

In large lake ecosystems (e.g., Lake Michigan), larval fish environmental experiences are influenced by climate-controlled physical transport processes. Water currents advect passive larvae throughout heterogeneous habitats and affect larval access to suitable (a)biotic environments. We hypothesize that a) prior to summer stratification relatively strong along shore currents associated with vertical thermal bars limit offshore transport of fish larvae and b) offshore transport is more influential later in the season as stratification progresses. To test this, we use a coupled and in-series climate, hydrodynamic, biogeochemical, and Lagrangian particle dispersion model to simulate hatch and passive transport of larvae throughout Lake Michigan. We evaluate historic and potential future patterns of climate-induced larval transport and assess consequences for overlap with suitable prey densities. Simulations confirmed expectations of increased offshore transport later in the season, with shift towards greater offshore transport occurring earlier during warm years. Retention of larvae in nearshore habitats during spring may have important implications for larval vital rates as simulated larvae retained nearshore experienced relatively high zooplankton densities. With climate change, phenology of offshore larval transport is expected to shift earlier in the year. The ability of larval fish to exploit nearshore resources may be dependent on spawning and emergence phenology shifting in a similar manner as transport phenology.

**Donnell Gasbarrini**, Toronto Zoo, Toronto, ON, Canada. **Positive Conservation Impact Through Community Science Projects Turtle Tally and FrogWatch Ontario.**

Community science initiatives are contributing to efforts led by concerned community members, consultants, and researchers, in addition to engaging members of the public. Our work highlights the insights gained and actions taken as a result of data submitted to the Turtle Tally and FrogWatch Ontario community science projects, operated by the Toronto Zoo. These are inventory projects that allow participants to submit observations and associated data on frogs, toads, and turtles, many of which are species-at-risk in Ontario. Data collected through these projects is used to mitigate a major threat shared by these species: road mortality. Awarenesscampaigns and mitigation structures are commonly pursued as a means of alleviating this threat. When considering the implementation of such structures along roads, evidence of mortality is often requested. The 1,000+ observations submitted annually by an average of 470 users of our projects have successfully provided this justification, and we have supplied nearly 170 wildlife crossing signs since 2019 for installation on private property, public roads, and government lands. These projects engage members of the public, increase understanding of focal species, and have led to positive conservation impact.

**Katherine Gaudreau**[1], Cherie-Lee Fietsch[1] and Greg Rose[2], [1]Bruce Power, Tiverton, ON, Canada, [2]WSP, Mississauga, ON, Canada. **Climate change and the effects of anthropogenic thermal effluent in Lake Huron (with ID 1219).**

Bruce Power operates two four-unit CANDU stations on Lake Huron, discharging thermal effluent via two surface water discharges into the Main Basin. The potential synergistic effects of climate change and thermal effluent discharges were assessed using MM5 climate modelling and a MIKE3FM Hydrothermal Model. Climate modelling assessed climate and lake conditions under current, and future 2030 and 2060 median and extreme warm scenarios. Modelling scenarios included existing operational conditions with thermal effluent discharge and non-operational conditions without thermal effluent discharge. Current modelling results were adjusted using measured temperature information to minimize model error. Results were compared to existing and modelled thermal benchmarks for 17 species of fish selected across warm, cool, and cold-water guilds based on Indigenous, commercial, recreational, and ecological importance. Physiological and behavioural adaptation to increased water temperatures associated with climate change cannot be reliably assessed using existing thermal benchmarks. The spatial extent of thermal benchmark exceedances within the local study area were summarized monthly for operational and non-operational scenarios under current measured climate conditions and future median and warm climate change scenarios.

This innovative process enables a systematic approach to the assessment of the potentially synergistic effects of climate change and anthropogenically generated thermal effluent on key fish species in Lake Huron.

**Shikshya Gautam**, Angelica Vazquez Ortega and Zhaohui Xu, Bowling Green State University, Bowling Green, OH, USA. **Analyzing the Effect of Lake Dredged Sediments as Farm Soil Amendment on Corn and Soil Health.**

Annually, millions of tons of sediments are dredged from the US lakes and federal navigation channels to maintain the economic activity of ports and harbors. About 1.5 million cubic yards of dredged material (DM) are excavated yearly from the Western Lake Erie Basin, Ohio. After the prohibition of open water dredged disposal, the state of Ohio is recommending finding beneficial uses including amending farm soils (FS). My research investigates whether different ratios of DM amending an organic farm soil enhances the soil and corn health. The research objectives are (1) to characterize the soil health (total organic and inorganic carbon, nutrients, bulk density, C: N:P ratio) and (2) to determine crop yield and corn health (total organic carbon, nutrients, above and below biomass length). Our soil blends consisted of 100% FS, 100% DS, 95% FS/5% DM, 90% FS/10% DM, and 80% FS/20% DM. Our results indicated that as the DM ratio increased, the cation exchange capacity and soil organic matter also increased. Furthermore, the above and below corn biomass weight was higher with increasing the DM ratio. In addition, the highest corn yield was observed in 100% DM. Hence, DM has the potential to be used as an agricultural substrate. The research will also help ascertain the required DM ratio suitable for amending farm soils.

**Ty Gehrke**[1] and Stephen Marklevitz[2], [1]Ministry of Natural Resources and Forestry - Lake Erie Management Unit, Port Dover, ON, Canada, [2]Ministry of Natural Resources and Forestry - Lake Erie Management Unit, Wheatley, ON, Canada. **Take only side scans, leave only wake – using technology to map broad-scale riverine fish habitats.**

Assessing and protecting riverine fish habitat is vital to sustain Lake Erie's socioeconomically important fishery. The vast distance of rivers can be an impediment to such efforts. However, technological advances in recreational side-scan sonars and satellite imagery, along with the use of small vessels (i.e. Jon boats, zodiacs and canoes) has made this possible. The goal of this project is to identify and map suitable spawning and juvenile habitats for native and invasive species in major Lake Erie tributaries. Non-intrusive side-scan sonar technology and the use of satellite imagery allows us to image and delineate substrates while at most, only leaving only the wake of the boat. Pairing temperature data with river flow models (i.e. HEC-RAS) is further allowing us to examine system wide flow and temperature regimes while limiting intrusion into the rivers. Combined, this work will allow us to create substrate, flow, depth and temperature layers of the river to identify the current suitable habitat and also forecast potential future impacts cause by climate change. In the end this will create a tool to inform fisheries management and habitat restoration actions for native and invasive species.

**Natalie Gervasi**[1], Zoe Miller[2], Yin Fan[3], Jacob Bruxer[3], James Kessler[4], Janna Hummel[5], Lauren M Fry[4] and Frank Seglenieks[6], [1]National Hydrologic Service, ECCC, Montreal, QC, Canada, [2]United States Army Corps of Engineers, Detroit, MI, USA, [3]National Hydrologic Service, ECCC, Cornwall, ON, Canada, [4]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, USA, [5]United States Army Corps of Engineers, Buffalo, NY, USA, [6]National Hydrological Service, ECCC, Burlington, ON, Canada. **Simulating Great Lakes outflows and water levels using an open source regulation and routing model.**

Canadian and U.S. scientists and engineers develop and maintain bi-nationally coordinated numerical models to simulate water levels and the flow of water through the Great Lakes – St. Lawrence River system. These numerical models are known as regulation and routing models because they propagate water supplies to water levels and outflows using outflow regulation plans and simple hydraulic relationships. These regulation and routing models are critical operational and research tools used for outflow regulation and

forecasting operations of the International Joint Commission's Great Lakes boards. They are also used for regulation plan formulation and evaluations by the Great Lakes – St. Lawrence Adaptive Management Committee. However, the existing models are disjointed, laborious to maintain, and have several shortcomings from a software and community modeling perspective. These issues are being addressed by modernizing the existing models. We borrow design patterns from software engineering to unify the models, expand existing functionality, improve organization, reduce maintenance needs, and promote software longevity. Additionally, our approach will more readily allow end-users to test modified or new water management strategies, simulate a broader range of hydrological conditions, and import specific modules into their own programs or scripts. The result of this work will be a bi-nationally coordinated Great Lakes regulation and routing Python software package that is flexible, extendable, fully-documented, user-friendly, and open-source.

**Dominique S Gilbert**[1], Brett Hayhurst[2] and Nathan C Eddingsaas[3], [1]Construction engineering Research laboratory, US Army Engineer Research and Development Center, Champaign, IL, USA, [2]Department of Natural Resources & the Environment, Cornell University, Ithaca, NY, USA, [3]School of Chemistry and Materials Science, Rochester Institute of Technology, Rochester, NY, USA. **A bellwether for microplastic deposition in wetland catchments in the Great Lakes region.**

The largest freshwater system in North America, the Great Lakes, span hundreds of miles between Canada and the United States. Though much attention has been given to microplastic (MP) contamination in saltwater environments, it is believed that freshwater environments like the Great Lakes also have high levels of MP pollution that pose similar environmental and health risks. This study is intended as a bellwether for the presence of MPs in Great Lakes wetlands. In 2020, 27 bed sediment, 18 surface water, and 5 rainwater samples were collected from wetland catchments in the Horicon-WI, Seney-MI, Shiawassee-MI, Ottawa-OH, and Montezuma-NY National Wildlife Refuges (NWRs) in the Great Lakes region. Samples taken from these NWR locations are indicators of MP deposition in Great Lakes wetland catchment areas and potentially the greater region. MPs were extracted from samples and categorized by particle type (fibers, fragments, films, and spheres) and polymer type (PET, PP, PS, PE, PVC, acrylic, and other). Abundance of MP particle types and relative abundance of MP polymer types in each sample were determined. Average MP particle abundances for each sample type (bed sediment, surface water, and rainwater) at each NWR were also calculated. The study found average particle abundances ranged from 344-538 particles/kg sediment (dry weight) in the bed sediment samples, 4-68 particles/$m^3$ of water in the surface water samples, and 14-147 particles/$m^3$ of water in the rainwater samples, suggesting that MPs are pervasive in the Great Lakes region and surrounding wetland areas.

**Emily Giles**, WWF-Canada, Ottawa, ON, Canada. **Applying Priority Threat Management to Maximize Benefits for Biodiversity and Climate in Ontario.**

Action is urgently needed to recover species and reduce climate change, particularly in Ontario where there are many species at risk and a multitude of threats across terrestrial and freshwater ecosystems. Priority Threat Management (PTM) is a conservation decision-support framework that incorporates the costs, benefits, and feasibilities of conservation actions to determine priority strategies that will help the greatest number of species within a given region. It helps to facilitate an ecosystem approach to conservation, prioritizing conservation actions rather than individual species, to maximize recovery. WWF-Canada and our partners at University of British Columbia are conducting a PTM analysis in Southern Ontario. Through this project, experts will help identify opportunities to restore and enhance ecological integrity, establish stronger partnerships, and work cooperatively to recover Ontario's species at risk. Additionally, considerations for how conservation strategies taken for wildlife conservation may also help address climate change have been included.

**Brian K. Ginn**, Lake Simcoe Region Conservation Authority, Newmarket, ON, Canada. **Fifteen years of nearshore monitoring on Lake Simcoe.**

Since 2008, Lake Simcoe Region Conservation Authority (LSRCA) has been monitoring the nearshore zone of Lake Simcoe, focusing on nutrient loading, invasive species, climate change, and the synergistic interactions of these key ecological stressors. This presentation will summarize 15 years of monitoring on the environmental status and trends in nearshore zone of Lake Simcoe, highlighting the changes recorded due to climate change (decreasing ice cover and warmer surface waters), invasive species (zebra and quagga mussels, starry stonewort), changes in the benthos, and the disconnection of phosphorus loading from in-lake nutrient / dissolved oxygen conditions. With many similarities to the Great Lakes, the environmental trends recorded on Lake Simcoe have direct comparisons to the larger lakes, as well as potential impacts to their environmental management strategies.

**Casey M Godwin**[1], Christine Kitchens[1], Andrew Camilleri[1], Paul Glyshaw[2] and Henry A. Vanderploeg[2], [1]Cooperative Institute for Great Lakes Research, University of Michigan, Ann Arbor, MI, USA, [2]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, USA. **Using contemporary optical properties to infer past changes in UV and visible light attenuation.**

Dreissenid mussels impact the attenuation of visible light wavelengths in Lake Michigan by removing seston that scatters and absorbs light. This leads to the hypothesis that expansion of Dreissena may have also affected attenuation of ultraviolet (UV) light. However, few measurements exist of UV light attenuation prior to invasion, so the magnitude of this effect is uncertain. We measured size-fractionated spectral absorptivity of seston and water near Muskegon MI during the 2021 CSMI field year. We normalized the absorbance attributable to particles in each size bin to the concentration of chlorophyll in the same bin, then simulated the effects of changing chlorophyll concentration on the attenuation in UV and visible wavelengths and the photic depth (1% of surface intensity). We found that a 50% decrease in total chlorophyll could increase photic depth by 15 m for PAR wavelengths, 4.1 m for 380 nm UV, and 0.63 m for 310 nm UV. This is attributable to the disproportionate effect of seston on total PAR attenuation compared to UV attenuation. Seston contributed 63% and 37% of total PAR attenuation for seston < 20μm and < 5 μm, respectively, but 20% and 15% of total attenuation at 310 nm. These results support the hypothesis that Dreissena invasion and expansion affected visible light proportionally more than UV.

**Lee Grapentine**[1], Sophie Crevecoeur[1], Victoria Propp[2], Tammy Hua[2], James E Smith[2] and James W. Roy[1], [1]Water Science and Technology Directorate, Environment and Climate Change Canada, Burlington, ON, Canada, [2]McMaster University, Hamilton, ON, Canada. **Benthic zone assessments for aquatic ecosystems receiving groundwater plumes from landfills.**

Groundwater contaminant plumes from a variety of point sources, including landfills, are a potential risk to biota in receiving surface waters, particularly invertebrates in the benthic zone. Assessing contaminant exposure and impacts on benthic invertebrates is a challenge due to mixing of groundwater and surface water around the sediment interface, and potential confounding effects of other water quality and sediment properties (natural and human factors). These issues were addressed by a multiple-lines-of-evidence approach applied to an Ontario stream impacted by a historic landfill. Assessment components applied within and outside of the contaminant footprint included (a) sampling shallow groundwater to determine concentrations of a range of legacy (ammonium, metals, hydrocarbons, etc.) and emerging contaminants (PFAS, bis-phenols, pharmaceuticals, etc.), (b) sampling surficial sediment to determine benthic community densities and composition, (c) subsampling the sediment cores for microbial genomics analysis, (d) assessment of natural habitat potential cofactors (sediment particle size, water and sediment depths, stream velocity), and (e) in-situ toxicity testing of groundwater discharging across the sediment bed using caged invertebrates. This presentation will demonstrate these applications and discuss their successes and limitations, with the aim to provide guidance on assessments of aquatic ecosystem risk posed by

groundwater contaminants at the large number of landfills and other contaminated sites in Ontario and elsewhere.

**Tracie Greenberg**[1], Cal Buelo[2], Greg Koltun[3], Santina Wortman[2] and Daryl McGoldrick[1], [1]Environment and Climate Change Canada, Burlington, ON, Canada, [2]Environmental Protection Agency, Chicago, IL, USA, [3]U.S. Geological Survey, Ohio-Kentucky-Indiana Water Science Center, Columbus, OH, USA.
**Nutrient Loading in Lake Erie: A decadal update of trends.**

High levels of nutrients in Lake Erie have posed a threat to the lake ecosystem since the 1960's. Targets set forth in the original 1978 Great Lakes Water Quality Agreement (GLWQA) called for nutrient-related targets for the Great Lakes. Improvements were evident in the early 1990's but harmful algal growth increased significantly in Lake Erie recently, in large part due to increased Phosphorus delivered from major tributaries in the Erie watershed. Annex 4 of the amended 2012 Great Lakes Water Quality Agreement set targets to reduce total phosphorus and dissolved reactive phosphorus loads from priority tributaries. While nutrient loads in both countries are calculated annually by the governments of the United States and Canada to assess progress, the last published compilation of load estimates included data up to 2013. Updated binational phosphorus and soluable reactive phosphorus loading estimates from 2008 to 2021 are presented by year, country, basin, season and tributary.

**Janet Greenhorn**[1], **Carrie Sadowski**[1], Jennifer Rodgers[2] and Jeff Bowman[1], [1]Ontario Ministry of Natural Resources and Forestry, Peterborough, ON, Canada, [2]Ontario Ministry of Natural Resources and Forestry, Thunder Bay, ON, Canada. **Orthoimagery as a viable alternative to ground surveys for conducting muskrat house counts.**

The muskrat (*Ondatra zibethicus*) is often considered a ubiquitous inhabitant of Great Lakes coastal wetlands, but recent studies have indicated that muskrat populations across North America have been declining over the last 40–60 years. Monitoring of muskrat abundance is therefore an important task for wildlife managers, but traditional methods such as house counts conducted during ground-based surveys can be labour-intensive and time-consuming. Poor conditions or a lack of access may also limit how much of a wetland can be surveyed. Aerial imagery has previously been used to census a diverse array of wildlife populations but is not yet a common tool for muskrat surveys. To investigate the accuracy of this alternative survey method, we collected aerial photographs from coastal Lake Ontario wetlands for examination in both 2D orthorectified and stereoscopic formats. We compared muskrat house counts obtained from this imagery to counts obtained by ground survey crews in the same wetlands during the same winter. We found no significant difference between muskrat house counts obtained by ground survey crews and 2D orthoimagery observers. In contrast, stereoscopic imagery observers overestimated house counts compared to ground survey crews, which we interpret was due to an increase in false positives. The use of 2D orthoimagery is a promising non-invasive and low-impact tool for assessing muskrat occupancy and abundance in wetlands, provides comparable results to traditional ground survey methods, and may be preferable to wildlife managers for a variety of reasons.

**Andrew Gronewold**, Yifan Luo, Hannah Paulson, Maegan Muir and Justin Huber, University of Michigan, Ann Arbor, MI, USA. **Assessing Impacts of Climate Change on the Great Lakes' Future Water Balance.**

Climate change is causing significant and far-reaching impacts on the Great Lakes basin, including some recent rapid shifts between high and low in some water balance components. To understand potential climate change impacts on the future of the Great Lakes' water balance components (precipitation, evaporation, and runoff), we analyzed three plausible climate change scenarios. Each scenario is based on either historical trends or a synthesis of projected trends from the peer-reviewed literature. We found that climate change signals might already exist in the historical record, especially in precipitation. Our results

indicate that precipitation and evaporation are already likely to increase over the Great Lakes, causing the record highs and lows seen in recent years. Increases in both could only continue this oscillation between record highs and lows and possibly decrease the time between them. This raises the possibility of a tug-of-war on the water balance and rapid fluctuations between high and low water levels. However, increases in both work opposite each other and often don't dramatically change average long-term water levels. This study also shows that changes in water balance components are anticipated to vary by the lake and climate scenario. The findings suggest that the Great Lakes region will likely experience changes in the water balance due to climate change, which could have severe implications for the region's water resources, economy, and ecology.

**Ryan C Grow**[1], Michael Rennie[1], Friedrich Fischer[2] and Eric Berglund[2], [1]Lakehead University, Thunder Bay, ON, Canada, [2]Ontario MNRF, Thunder Bay, ON, Canada. **Taking a look at the upside: Using a stationary up-looking acoustic platform to examine fish ecology in Lake Superior.**

In the Great Lakes, standard down-looking acoustic surveys and capture-based surveys have been used to evaluate the status and trends of pelagic fishes. Acoustic surveys provide a non-destructive alternative to standard capture-based surveys which can have biases related to gear efficiency and fish density. However, the potential disturbance of fishes by survey ships associated with standard acoustic surveys introduces its own bias and can lead to underestimations of fish density. Additionally, these surveys do not provide adequate information on temporal fish movement patterns. To combat these issues, we deployed a stationary up-looking acoustic platform (Spider) in Thunder Bay, Lake Superior concurrently with a standard fall Cisco (*Coregonus artedi*) survey to assess the impacts of ship-based biases on fish density estimates. We then deployed the Spider across Lake Superior during the summer to assess the effects of daily cycles and spatial differences on fish movement patterns. Results from the fall deployments suggest that the Spider detected two times as many fish as the traditional survey. During the summer at night fish of all sizes moved from deeper to shallower waters and both large and medium sized fish slowed down while smaller fish sped up across all sites. Our results suggest that up-looking acoustic surveys are an important tool for improving fish density estimates and our understanding of fish ecology in large aquatic systems with low impacts on them and their habitat.

**Matthew Gruwell**, Allegra Cangelosi, Amanda Welsbacher, Abigail Melendez, Ryan Sheehan, Hannah Phillips and Ivor Knight, Penn State Behrend, Erie, PA, USA. **Development and Application of eDNA Probes for Rapid Identification of Four AIS in the Great Lakes.**

Reliable, timely and economical target organism detection in harbors and ballast water is urgently needed to prevent spread of aquatic invasive species (AIS) by commercial ships in the Great Lakes (GL). Laker ships transport large volumes (ca. 52 million metric tons) of untreated lake water from the lower lakes to Western Lake Superior and constitute the primary vector of AIS spread throughout the GL. eDNA detection and identification of target organisms could enhance control of ballast-mediated AIS spread through rapid detection. To that end, we developed species-specific reliable eDNA probes and qPCR protocols to detect four target AIS in whole water samples. Criteria for AIS selection were as follows: 1) they are known to be invasive in the lower GL; 2) they are established in the lower GL but not in Superior; 3) they are capable of being entrained and transported in ballast water; and 4) specimens are readily obtained, morphologically distinct and have existing DNA sequence information available. Following our criteria, we created and tested working eDNA probes for: *Daphnia lumholtzi* (a spiny waterflea), *Cercopagis pengoi* (the fishhook waterflea), *Nitellopsis obtuse* (Starry Stonewart), and *Echinogammarus ischnus* (a scud).

**Panditha V.S.L. Gunawardana**, Trent University, Peterborough, ON, Canada. **Estimation of metabolism in Lake Superior using autonomous underwater vehicle data.**

Inland waters are increasingly being recognized as a significant source of carbon (C) to the atmosphere. However, quantifying the fate of C in large lake ecosystems is inherently difficult, limiting our understanding of their role in the global C cycle. Autonomous underwater vehicles (AUVs) that collect real-time high-resolution vertical and lateral water quality data across large spatial scales have been used in marine metabolic studies. Over the last decade, AUVs have been used to conduct observation research through The Consortium of Great Lakes Gliders in the Laurentian Great Lakes. To assess the epilimnetic metabolic rates, we used 7 years of archived high-resolution AUV data from Lake Superior (LS), the world's largest freshwater lake by surface area. The AUV missions differed in location and span but were biased towards southern Lake Superior and summer. Continuous limnological data collected by AUVs (i.e., dissolved oxygen and temperature) and meteorological data (i.e., wind and solar radiation) were used to estimate daily epilimnetic gross primary production ($0.32 \pm 0.49$ g $O_2$ $m^{-3}$ $day^{-1}$) and ecosystem respiration ($-0.50 \pm 0.60$ g $O_2$ $m^{-3}$ $day^{-1}$) using established methods. Compiling all these data, LS was net heterotrophic (net ecosystem metabolism $-0.17 \pm 0.53$ g $O_2$ $m^{-3}$ $day^{-1}$) while exhibiting some spatial and temporal variation. Although metabolic rates for LS are low compared to many other large lake ecosystems, given the size of LS, the present study reveals that it can have a substantial contribution to the global C cycle.

**Megan L. Gunn**, Purdue University, IL-IN Sea Grant, West Lafayette, IN, USA. **Freedom Seekers and the Great Lakes: connecting the history of our land to current education efforts.**

To educate about the current state of the Great Lakes, it is also necessary to look at their history. Through a cross curricular, collaborative effort between educators from across the Great Lakes basin, a new curriculum was recently created. 'Freedom Seekers: The Underground Railroad, Great Lakes, and Science Literacy Activities' connects middle and high school students to the rich history of the Great Lakes while also engaging them in current restorative efforts. The curriculum focuses on how freedom seekers were not just enslaved peoples seeking freedom. And with this focus, students learn how freedom seekers were also environmentalists, scientists, and inventors that navigated the land and the Great Lakes and how this part of their history has been erased. Through this presentation, the audience will learn how the curriculum committee and collaborators are engaging with educators and organizations, including those that are reaching students from traditionally underserved and underrepresented populations, to ensure these lessons are also in the hands of those that could be most positively impacted by the representation shown in the lessons. We will also share a few characteristics of our successful initiative, which include workshops to educate educators on how to navigate and use the resource, the wealth of background resources for the educators to learn more about each lesson before teaching it, the incorporation of local examples to connect students through a more place-based learning experience, and how we ensured the curriculum is free and open access.

# H

**Sydney Hall** and Gregory L. Boyer, SUNY Environmental Science and Forestry, Syracuse, NY, USA. **Analysis of the LightDeck Biosensor for Cyanotoxins in Freshwater Samples.**

Harmful algal blooms are a severe expanding problem due to anthropogenic eutrophication and climate change stressors. Freshwater cyanobacterial blooms can produce cyanotoxins such as microcystins, anatoxins, cylindrospermopsins, and saxitoxins. These cyanotoxins have negative impacts on human health. The conventional methods for determining the concentration of these cyanotoxins in a water sample require a sample to be collected and returned to the laboratory for analysis. There is a need for a mobile detection system that can provide results in near-real-time. An innovative planar waveguide biosensor was developed by LightDeck to meet this need for easy, mobile, and quick cyanotoxin detection. Here we report on a side-

by-side comparison of this new technology with traditional LC-MS/MS monitoring techniques. Samples were collected at biweekly intervals by citizen volunteers from two lakes in Central New York (Lake Canandaigua and Lake Chautauqua) and submitted to the laboratory for analysis. Both lakes experienced harmful algal blooms in 2022 that contained measurable amounts of microcystins. The LightDeck system is capable of detecting microcystin (0.5-4.0 ug/L), cylindrospermopsin (0.7-3.0 ug/L), and saxitoxin (0.6-2.0 ug/L). However, no neurotoxins were found in either lake during 2022. A comparison of the microcystin results will be presented. Further studies will include field deployment of these sensors and a rapid monitoring system for cyanotoxins.

**Lauren Alicia Halliwell**[1], Leon Boegman[1], Pascale Champagne[1], Geoffrey Hall[1] and Hamidreza Shirkhani[2], [1]Queen's University, Kingston, ON, Canada, [2]National Research Council of Canada, Ottawa, ON, Canada.
**Modelling impacts of climate change on a Wastewater Stabilization Pond discharging into the Lake Ontario Watershed.**

Since the 1970s, more than $10 billion have been invested in Canada, to reduce nutrient polluted wastewater effluent from discharging into the Great Lakes and their watersheds. This included the development of Wastewater Stabilization Ponds (WSPs), which are common treatment systems for smaller communities. WSPs utilize natural ecological cycles to breakdown and treat wastewater in an economical and practical way. However, one major uncertainty with WSPs is their efficacy under the impacts of climate change. Specifically, how will WSPs be impacted by the projected temperature increase of 5.9°C by 2100 – over a two-fold increase from the previous decade. Temperature changes will impact both hydrodynamics, by altering the thermal stratification, and biogeochemistry, by impacting the temperature dependent rate equations. In this study, a WSP in southeastern Ontario was modelled using a coupled Delft-3D Flow (hydrodynamic) and WAQ (water quality) model to replicate pond operation. The model shows similar trends for all water quality parameters including, water temperature with an r^2 of 0.42. This numerical model will simulate predictive scenarios for future climate change impacts including, 5-year, 10-year and 25-year increase in the future. The simulations will be insightful to effectively understand how these water systems will operate and to protect the surrounding watersheds in the future.

**David Hamilton**[1], Songyan Yu[1], Tony Weber[2] and Katrin Fluggen[3], [1]Australian Rivers Institute, Griffith University, Brisbane, QLD, Australia, [2]Alluvium Ltd, Brisbane, QLD, Australia, [3]Seqwater, Brisbane, QLD, Australia. **A coupled catchment-lake model to assess water quality challenges from climate change in an Australian reservoir.**

The hydrological connection of catchments and lakes is critical for contaminants like pathogens, particularly in subtropical regions where flow and pathogen loads can be intermittent and difficult to quantify with conventional sampling strategies. Modelling therefore plays a key role in providing information about the fate and transport of pathogens through catchments, including when to sample and the implications of increased rainfall variability associated with climate change. We show outputs from a coupled catchment (Source) and three-dimensional lake (AEM3D) model to demonstrate the spatial and temporal changes in pathogen concentrations from their source in different subcatchments to the dam offtake of a large subtropical water supply reservoir (Lake Wivenhoe, Brisbane, Australia). We demonstrate the impacts of intermittency of rainfall, thermal stratification and in-reservoir pathogen decay rates. Climate change poses additional challenges for managing pathogens because of potential for short-circuiting and rapid transport of the pathogens to the dam wall, particularly when inflows insert along the thermocline. Our insights into the fate and transport of pathogens emphasize the importance of using coupled catchment and lake models driven by selected meteorological scenarios to provide insights into catchment and reservoir management approaches.

**Scott Hansen**[1], Daniel Dembkowksi[2], Patrick Forsythe[3], Taylor Hrabak[3], Daniel Isermann[2] and Lisa Izzo[2], [1]Wisconsin Department of Natural Resources, Sturgeon Bay, WI, USA, [2]University of Wisconsin - Stevens Point, Stevens Point, WI, USA, [3]University of Wisconsin - Green Bay, Green Bay, WI, USA. **Managing lake whitefish in Wisconsin waters of Lake Michigan – a tale of two waters.**

Nearly 20 years have passed since a major shift in lake whitefish production and commercial effort commenced in the waters surrounding Wisconsin's Door Peninsula. Recruitment from the state's long-storied Lake Michigan stock, centered around the areas of North and Moonlight Bays, began a decline that was consistent with most other Lake Michigan stocks. Meanwhile, a southern Green Bay meta-population was in the early stages of a substantial rebuild after a century-long recession. The Wisconsin DNR's historical management approach to a single-source spawning stock harvested in traditional areas gradually became less relevant as commercial effort followed whitefish distribution. The concurrent emergence of a substantial recreational whitefish fishery on Green Bay created a novel shared fishery, further confounding the issues. The evolution of these fisheries has brought on major changes in management of harvest and effort as well as an increased need for research data to inform decisions. This presentation will describe these changes in Wisconsin's lake whitefish fisheries on Lake Michigan over the past two decades and the resulting management actions and research activity.

**Tim JE Hollinger**[1], Jennifer Korosi[2] and **Dale Hardy**[3], [1]Lakehead University, Thunder Bay, ON, Canada, [2]York University, Toronto, ON, Canada, [3]Rocky Bay First Nation, Rocky Bay First Nation, ON, Canada. **Biinjitiwaabik Zaaging Anishinaabek Lake Nipigon Project.**

BZA-Rocky Bay has long had concerns regarding resource development and extraction within the Lake Nipigon Basin. The community has felt the brunt of impacts from development including mining in the Greenstone Gold belt and hydroelectric development in the Ogoki Diversion, Namewaminikan River Dams and Nipigon River Dams. Observed effects include relocation of the community due to flooding, large-scale changes in Lake bathymetry, contamination of traditional food sources, declines in fish populations and erosion of culturally significant sites. This project has focused on community driven efforts to understand contemporary and historical lake conditions. By touring the lake with community members including fishermen and elders, fish communities have been assessed for metals of major concern to the community such as mercury and arsenic while sharing knowledge and making connections across the lake. We have also collected sediment cores from several nearshore areas and bays of Lake Nipigon, to add a western science perspective on long-term ecosystem changes over the last ~70-200 years. Lake sediments archive a wealth of material and information that can be used to indirectly infer past environmental conditions. Cores are being analyzed for metals (including mercury), as well as biological and geochemical proxies for lake productivity and other water quality parameters. As the community looks ahead to continue its Guardian Initiative we plan to use these data to guide management through networking further with the other Indigenous communities of Lake Nipigon.

**Julia Harig**, Kelly Hoyer and Andrew Scott McNaught, Central Michigan University, Mount Pleasant, MI, USA. **Basal respiration rates of larval *Coregonus clupeaformis* and *C. artedi*.**

Lake Whitefish and Cisco are important to the Great Lake's ecosystem and commercial fishing. While Lake Whitefish populations have been decreasing due to poor recruitment, Cisco populations have begun to increase in some regions following improved recruitment. Poor recruitment may be explained by extremely low food resources in nearshore habitats during the spring. When food resources are low, small differences in respiratory demand between larval Lake Whitefish and Cisco may result in different growth and survival rates between the two species. Unfortunately, little information exists on basal respiration rates of larval Lake Whitefish and Cisco. We measured oxygen consumption rates of 15 and 30 mm larvae at 8 and 10°C in circular chambers (2, 15 mL) using a Firesting FSO2 respirometer. Oxygen was measured for 60 seconds every hour for eight hours. Between measurements, oxygenated water was pumped through the chambers. Fish were measured, dried, and weighed. Oxygen consumption rates were variable and changed

with fish size and temperature. Slight differences in basal respiration rates between Lake Whitefish and Cisco may provide Cisco excess energy for growth and survival thereby explaining the increasing population of Cisco compared to Lake Whitefish.

**Paul Harpley**[1], Ian Hilton[1] and Rob Milne[2], [1]The Zephyr Society of Lake Simcoe, Pefferlaw, ON, Canada, [2]Wilfrid Laurier University, Waterloo, ON, Canada. **Probing the Land/Water interface at rivers and streams: South Lake Simcoe, Sand and Clay plain landscape.**

The land/water interface at rivers and streams is of ultimate importance for river to lake water quality and buffering phosphorous, nitrogen and sediment loading into Lake Simcoe. The Zephyr Society of Lake Simcoe with science partners has been undertaking Small Area studies for over two decades in the Black and Pefferlaw Rivers watersheds. Research has focused on slow moving meandering riparian areas often with man-made dam impoundments on central-mid river sand and clay plain reaches. These sites are surrounded by extensive natural areas, intensive to low impact agriculture. Periodically these river areas increasingly show poor water quality effects of point and non-point sources commercial fertilizer, biosolid spreading producing documented episodic eutrophication events. Climate change increasing temperature, intensifying rain/weather events, erosion effects on river reaches and riparian morphological change is probed by this research. Periodic macro-invertebrate biomonitoring was undertaken. Focused results of surveys will be reported and will be discussed with respect to an adjacent Zephyr Society restoration project supported by a federal Lake Simcoe Clean-Up Fund (LSCUF) and completed in 2010, reporting landscape change in the last decade. Additionally, aquatic mammals research (beaver and muskrat) role in river morphology change and long-term research management recommendations of shoreline restoration, bioengineering planning and re-wilding will be reported, in the context of future policy direction in a climate changing world.

**Anna M Harrison**, Amanda K. Suchy and Donald G. Uzarski, Central Michigan University, Mount Pleasant, MI, USA. **Influences of lake connectivity and site conditions on heavy metals in Great Lakes coastal wetlands.**

In the Great Lakes region, coastal wetlands can retain contaminants sourced from the landscape, preventing them from entering lake environments. However, by retaining contaminants in wetland sediments, these sediments can become sinks for pollutants as they accumulate over time, creating ecological risk for the biota that reside in and utilize these critical ecosystems. Heavy metals are naturally occurring at low concentrations, however much of the metals founds in aquatic ecosystems today are a result of anthropogenic inputs from legacy contamination and modern use of metal-containing products that enter waterbodies via runoff. The amount of wetland connectivity to both the lake and landscape may influence the degree to which wetlands accumulate metals, as wetlands with greater connectivity to the landscape and less connection to the lake may be more susceptible to metal contamination. Our study sampled sediments in 30 coastal wetlands within Lakes Michigan, Huron, and Erie for metals. Metals varied by wetland connectivity to the Great Lakes, as Pb, Cu, Cr, and Co concentrations were highest in barrier protected wetlands, followed by riverine wetlands, and lowest in lacustrine wetlands. Higher metal concentrations were also associated with lower pH and lower water clarity in the surface waters. By understanding the physical and chemical conditions in coastal wetlands associated with high metal concentrations, we can better predict where metal contamination may occur and how climate change may influence metals in Great Lakes coastal wetlands.

**Tyler J. Harrow-Lyle**[1], Krista M. Chomicki[2] and Andrea E. Kirkwood[3], [1]Environment and Climate Change Canada, Burlington, ON, Canada, [2]Toronto and Region Conservation Authority, Vaughan, ON, Canada, [3]Faculty of Science, Ontario Tech University, Oshawa, ON, Canada. **Identifying climate and seiche influences on phosphorus loadings in coastal wetlands on Lake Ontario.**

Great Lakes coastal wetlands are essential land-water linkages, which regulate the fate of materials and nutrients from watersheds prior to discharge into the nearshore zone of the Great Lakes. With climate change increasing storm activity and wind events within the Great Lakes Basin, a fulsome understanding of nutrient processing and fate within coastal wetlands is essential. We evaluated across- and – within wetland water quality and nutrient loadings as a function of climate and seiche activity over a decade (2009-2018) in three drowned river mouthed wetlands of Lake Ontario. Notably, celled sites had significantly higher concentrations of total phosphorus, phosphate, and organic nitrogen compared to non-celled sites (permutational analysis of variance p-value < 0.001). These differences were associated with increased solar radiation and lake level variability (i.e., seiche inundation), thus we infer celled sites are important locations for the mobilization of legacy phosphorus. To further characterize the relative effect seiche activity has on phosphorus loadings to the nearshore zone of Lake Ontario, we developed a structural equation model. We confirmed that seiche events resuspend sediments, which cause a significant increase of phosphorus loadings to the coastal zone of Lake Ontario (p-value < 0.001). Our results indicate that climate and seiche events influence coastal wetland water quality and should be considered when assessing nearshore zone water quality.

**John H. Hartig**, University of Windsor, Great Lakes Institute for Environmental Research, Windsor, ON, Canada. **The role of boundary organization networks in implementing ecosystem approach frameworks.**

There is a clear need to strengthen science-policy-management linkages in Great Lakes management. The ecosystem approach is widely accepted throughout the Great Lakes research and management communities and holds much promise for strengthening science-policy-management linkages. However, there is a gap between the ecosystem approach vision and management reality. More work is needed to identify and disseminate effective ecosystem approach implementation frameworks. Key elements of an implementation framework include: establishing a vision for change; engaging stakeholders; building capacity; creating a plan with measurable goals and clear priorities; and implementing the plan and striving for continuous improvement through adaptive management. Boundary organization networks are strengthening science-policy-management linkages through co-production of knowledge and co-innovation of solutions. Great Lakes Areas of Concern are a good example of the evolution of boundary organization networks to restore impaired beneficial uses.

**Eden Hataley**[1], Hayley McIlwraith[2], Dimple Roy[1,3] and Chelsea Rochman[1,2], [1]University of Toronto Scarborough, Toronto, ON, Canada, [2]University of Toronto, Toronto, ON, Canada, [3]International Institute for Sustainable Development, Winnipeg, MB, Canada. **Towards a management strategy for microplastics in the Great Lakes – Monitoring and risk assessment.**

This presentation will summarize the findings of two papers recently submitted for publication on the state of the science relating to microplastic contamination and risk in the Great Lakes. In our first paper, we synthesize the research published across the region, reporting on contamination, areas that have been the focus of study, and the methods used across matrices. We discuss the need for a basin-wide monitoring program with standardized protocols for sampling, analysis, and reporting and how the current body of research may inform these guidelines. In the second paper, we demonstrate the application of a published risk assessment and management framework for microplastics in aquatic ecosystems by comparing proposed thresholds for ecological risk (relevant to two hypothesized mechanisms of microplastic toxicity, food dilution and tissue translocation) to local monitoring data available in the primary literature. Based on our results, we discuss the need for better management of microplastics in the Great Lakes to reduce current ecological risk. Both papers conclude that it may be time to address microplastic pollution under the Great Lakes Water Quality Agreement, either by designating microplastics as a Chemical of Mutual Concern under Annex 3 or including them as a Toxic Chemicals sub-indicator under the State of the Great Lakes reporting. As a next step, we suggest convening a workgroup of local experts to develop a monitoring

strategy and a risk assessment and management framework comprising risk thresholds for surface water and sediment for the region.

**Julia Hatcher**, Jody McKenna and Jocelyn Sherwood, Environment and Climate Change Canada, Burlington, ON, Canada. **The first ever cumulative assessment of the Canadian Great Lakes nearshore waters.**

The nearshore waters of the Canadian Great Lakes have lacked a comprehensive, standardized assessment of cumulative stressors, hindering the ability to identify and prioritize areas needing remediation or protection. In response, Environment and Climate Change Canada conducted the first ever cumulative impacts assessment of the nearshore waters of 8500 km of Canadian Great Lakes coastline, using a weight-of-evidence approach to evaluate stress from impaired coastal processes, contaminants in water and sediment, nuisance and harmful algae, and impacts on human use. Results revealed that of the 64 nearshore regions, three were under high stress, 45 were under moderate stress, 15 were under low stress, and one was under very low stress. This assessment provides crucial information for resource managers, policymakers, and the public on nearshore threats and areas that would benefit from protection, restoration, or prevention efforts, especially in light of the exacerbation of stressors due to a changing climate. The novel data and information from the assessment are publically available to support informed decision-making at all levels of government, to promote effective management and protection of freshwater resources and ecosystems now and in the future, and to support active engagement of Canadians in freshwater resource management.

**Emily Hawton**, Bill Thompson and Kaitlyn D Read, Lake Simcoe Region Conservation Authority, Newmarket, ON, Canada. **Do nature-based climate solutions matter in urbanizing areas?.**

Nature-based climate solutions have the potential to play an important role in both lessening the local impacts of climate change, as well as reducing the severity of climate change globally through their sequestration and storage of carbon. However, nature-based climate solutions may play less of a role in offsetting emissions in an urbanizing area like central Ontario, than they would in more natural or rural areas. Research on carbon sequestration rates by natural areas in the Lake Simcoe watershed suggests that they sequester approximately 20% of the greenhouse gases currently emitted in the watershed. As growth and development proceed however, the rate of emissions may increase at the cost of sequestration, without ensuring adequate protection and expansion of natural areas. This presentation gives an overview of research that the Lake Simcoe Region Conservation Authority has underway to quantify the role of wetlands in addressing greenhouse gas emissions locally, through carbon sequestration and storage, as well as the potential the conservation authority and its partners have to contribute to that sequestration through ongoing wetland restoration.

**Tim Haxton**, Ontario Ministry of Natural Resources and Forestry, Peterborough, ON, Canada. **Biological characteristics of inland lake whitefish populations in Ontario.**

Contemporary biological characteristics for inland lake whitefish populations in Ontario are relatively unknown. Populations in the Great Lakes have declined from a synergy of perturbations, but it is unknown if the effects are landscape wide. A Broadscale Monitoring (BsM) program has been conducted within inland lakes in Ontario since 2008 in approximately five-year cycles on approximately 750 lakes. The objectives of this study were to assess the biological characteristics of lake whitefish within inland lakes at multiple scales and determine if there have been any changes in abundance spatially and temporally over 15 years. Since BsM's inception, 54 941 lake whitefish were sampled among 524 different waterbodies. Lake whitefish relative abundance of did not vary among cycles, however, varied among FMZs but not within a FMZ among cycles. They were more abundant in lakes with less species diversity, greater Secchi depth and mean depth, and higher levels of hypolimnetic dissolved oxygen. Abundance was greatest at the 12 – 35 m depth strata whereas the probability of catching a lake whitefish was greatest at the 12 – 20 m depth stratum.

There was no spatial segregation based on size as the mean length did not vary among depth strata. Growth, age and size at maturity was similar between the sexes at the provincial and FMZ scale. Mean survival for populations with at least 50 lake whitefish sampled was 83%. The demographics and relative abundance of lake whitefish throughout inland lakes in Ontario is indicative there is currently limited exploitation on these populations.

**Brett Hayhurst**[1,2], Dan Breneman[3], Kristen Buscaglia[4] and Karen Keil[5], [1]US Army Engineer Research and Development Center, Ithaca, NY, USA, [2]Department of Natural Resources & the Environment, Cornell University, Ithaca, NY, USA, [3]Minnesota Pollution Control Agency, Minnesota, MN, USA, [4]U.S. Army Corps of Engineers-Buffalo District, Buffalo, NY, USA, [5]US Army Engineer Research and Development Center, Buffalo, NY, USA. **Assessing estuary aquatic habitat and biological community health to select areas for protection or restoration.**

The St. Louis River Estuary including Duluth-Superior Harbor is the largest estuary in the Great Lakes as well as an Area of Concern. Several beneficial use impairments are legacies of industrial activities and have been the focus of sediment remediation and habitat restoration for many sites throughout the estuary. Natural resource management strategies in the St. Louis River estuary are currently transitioning from federal Area of Concern program priorities to longer-term monitoring and maintenance responsibilities led by the state. Habitat conditions are being documented estuary-wide in order to identify areas of habitat warranting further protection or restoration. A suite of physical, chemical, and biological data sets were used in an analysis effort that describes a gradient of environmental condition across eight longitudinally-defined geomorphic zones within the estuary. Statistical and spatial analysis techniques were used to create rankings based on individual measures of environmental health compared to an established least-impaired, reference condition. Healthy vs. poor habitat can be identified by combining associated metrics and visualizing in GIS. This conceptual tool can help advance planning within an estuary to inform managers of locations warranting protection, or further restoration.

**Issac Hebert** and Erin S. Dunlop, Ontario MNRF, Trent University, Peterborough, ON, Canada. **Annual variation in the diet of larval lake whitefish (*Coregonus clupeaformis*) from the Fishing Islands of Lake Huron.**

There has been increased interest in the early life stages of lake whitefish (*Coregonus clupeaformis*) because of the steep declines in recruitment across many regions of the Laurentian Great Lakes. Lake Huron has experienced major ecosystem changes which could be affecting the feeding ecology of this vulnerable life stage. Specifically, observed declines in zooplankton biomass and species richness could be contributing to poor growth and survival of larval lake whitefish. This study examines annual variation and ontogenetic shifts in diet, feeding strategy, and prey preferences of larval lake whitefish. Zooplankton and larval lake whitefish were collected in the spring of 2017 to 2019 and 2021 using pelagic trawls at the Fishing Islands spawning shoal complex in Lake Huron. The digestive tracts of larvae were extracted, and the contents were identified, enumerated, and measured to calculate prey composition and preference. We found that the diet of lake whitefish became more specialized with larval length, showed annual and individual variation and no prey type dominated the diets of larval fish. Calanoid copepods were preferred some years while nauplii were consistently avoided. Copepods were the most frequent prey and insects were common prey and were at times greater than 10 % of larval body length. These results suggest that larval lake whitefish diets are variable, show individual specialization, and show a preference for copepod prey. Our next steps will be to examine the degree to which prey availability affects feeding success, growth, and recruitment.

**Paul Helm**, Melanie Raby, Sonya Kleywegt, Ryan J. Sorichetti, Derek Smith, Edward Todd Howell, Grace Arabian and John Thibeau, Ontario Ministry of the Environment, Conservation and Parks, Toronto, ON,

Canada. **Tire-additive transformation product 6PPD-quinone in Lake Ontario urban watersheds and receiving waters.**

Urban stormwater is a conduit for nutrients, pathogens, and pollutants such as tire-wear compounds to nearshore Great Lakes receiving waters. A transformation product of the anti-ozone compound 6PPD in tires, 6PPD-quinone (6PPD-Q), has been implicated in causing fish mortality. In this study, surface waters from Lake Ontario urban tributaries and nearshore waters of Toronto and Hamilton, Ontario, were sampled to assess whether 6PPD-Q was present at levels that may impact aquatic health. Stream samples were collected during wet-weather flows and dry conditions during fall and spring seasons in 2021-2022, overlapping with fish spawning times, and analyzed for 6PPD-Q and water chemistry parameters. Concentrations of 6PPD-Q were elevated during wet-weather, reaching a maximum concentration of 82 nanograms per liter (ng/L), and were highest in streams with the greatest degree of urbanization. Concentrations were low (<2.0 ng/L) in nearshore waters, suggesting rapid dilution. Precipitation and road density within watersheds were positively correlated to 6PPD-Q concentrations and other road contaminants (e.g. chloride from road salts). A screening level hazard assessment using safety factors (Hazard Quotient of 0.1) and available toxicity endpoints for fish (rainbow trout, brook trout, coho salmon), shows that 6PPD-Q concentrations in urban streams exceed protective levels for fish in wet-weather. These results support the need for further assessment of Ontario streams, particularly where trout habitat is influenced by road run-off.

**Clare T Helmer**, Kent State University, Kent, OH, USA. **Investigating eutrophication as a driver of methanogenesis in the western basin of Lake Erie.**

Increased blooms of cyanobacteria have been plaguing Lake Erie in recent decades, having profound negative impacts on the regional environment. These blooms deliver organic carbon to the lakebed, which can drive the consumption of oxygen and other oxidants through respiration within sediments. Emissions of the greenhouse gas methane from Lake Erie have been studied but have yet to be directly linked to eutrophication and sedimentary production in the Great Lakes. The hypothesis of this study is that algal blooms in Lake Erie are contributing to an increase in methane fluxes from the lake to the atmosphere due to the process of sedimentary methanogenesis. Sediment and pore water data were analyzed from samples collected from two sites in the western basin during the 2021 and 2022 summer months. Findings suggest that methanogenesis is taking place at relatively shallow depths below the lakebed (within 10 centimeters of the sediment water interface). Thus, there is potential for substantial methane release to the water column. The shallow depth of methanogenesis also suggests that oxidants are being rapidly consumed within centimeters of the sediment water interface. The results of this study determined that eutrophication of Lake Erie is most likely contributing to methane production.

**Hayden Henderson**[1], Pengfei Xue[2] and Russ Miller[3], [1]Great Lakes Research Center, Michigan Technological University, Houghton, MI, USA, [2]Michigan Technological University, Houghton, MI, USA, [3]Cooperative Institute for Great Lakes Research (CIGLR), Ann Arbor, MI, USA. **The glider flies while data drives: Assimilation and deep learning with high-resolution AUV data.**

While in-situ measurements and remotely sensed data have been commonly used for Great Lakes hydrodynamic model initialization and verification, it is less commonly incorporated into 3D models during simulations to improve model performance via a data-model fusion framework. Autonomous underwater vehicles, such as Slocum gliders, can gather water column physical and biochemical data from near-surface to depths of hundreds of meters, effectively able to be used as mobile profiling platforms with a flight persistence of weeks to months. Despite the presence of gliders in the Great Lakes with various observational foci for over a decade, their high-resolution datasets of scientific parameters, such as temperature, dissolved oxygen, or chlorophyll, have not been routinely applied to model improvement. The establishment of ingestion workflows for these datasets, as well as synergizing glider deployments with data-driven model objectives, will significantly improve physical and biogeochemical model performance. A

description of the initial success using glider data with FVCOM, as well as the next steps, including deep learning possibilities, is given here.

**Michael Hennessy**, USEPA Great Lakes National Program Office, Chicago, IL, USA. **Developing more robust resources for underserved communities in Great Lakes AOCs.**

This talk would would have 3 parts. 1) A summary of USEPA GLNPO's recent efforts to provide more robust Environmental Justice benefits for underserved AOC communities. I'd cover on-the-ground visits with communities, listening sessions with EJ leaders, potential funding opportunities, and more. 2) An example of successful EJ/DEI implementation on a GLNPO funded project (related to potential funding opportunity). This will cover our project priorities and parameters as well. And 3) a highlight of our EJ Resource Library tool that we will be releasing in the spring. This will be a central location for case studies, best practices, interactive maps, and other resources that highlight successful EJ/DEI implementation in Great Lakes AOC communities. It's our intention to build linkages between the different states and local groups working to develop their EJ/DEI programs.

**Taylor Nicole Herne**[1], Sarah Diane Lawhun[2], Lyubov Burlakova[3], Alexander Y. Karatayev[3], Patrick V Boynton[1], James M Watkins[1] and Lars G. Rudstam[1], [1]Cornell Biological Field Station, Bridgeport, NY, USA, [2]Cornell University, Ithaca, NY, USA, [3]SUNY Buffalo State, Buffalo, NY, USA. **Shrimp on Film - Utilization of Benthic Habitat by *Mysis diluviana* in Lake Michigan.**

*Mysis diluviana* are a key species in the Great Lakes food web, serving as a prey item for numerous fish and also as a predator for smaller zooplankton. This species spends much of their time during the day on the benthic floor then migrates from the benthic to the pelagic at night, forming a distinct layer near the thermocline, though there are known deviations to this behavior. Long-term monitoring efforts focus solely on population abundance estimates calculated from nighttime whole water column net tows. Net based monitoring of the population of mysids in Lake Michigan has suggested a recent decline from 2016-2019. Using an extensive (>100 sites) lake-wide benthic sampling survey of Lake Michigan in July 2021, we explored the use of benthic Ponar grabs as a mysis collection method and the resulting population estimates were compared with those of traditional vertical net tows. Benthic collections were conducted day and night allowing us to evaluate diel vertical migration (DVM) patterns and benthic habitat utilization. Concurrent drop-down camera videos at all sites confirmed these benthic abundance estimates and provide insight into mysid behavior on the benthic floor.

**Netami Stuart**, **Joey Herrington** and Jennifer Ogrodnick, Waterfront Toronto, Toronto, ON, Canada. **Creating new habitat through an urban brownfield and how to protect it.**

The Port Lands Flood Protection (PLFP) project includes the construction of over 1 km of new naturalized river valley that extends from the mouth of the Don River through a former industrial (brownfield) area. The project is part of a comprehensive plan to protect the city's downtown from flooding during a regulatory storm event and facilitate redevelopment. The project involves the creation of a new, multi-outlet river valley through a combination of cutting into the existing contaminated soils and raising the grade of adjacent lands. The placement of poor-quality historical lakefill over native lacustrine marsh soils (consisting of unconsolidated sand, peat and organic silts), combined with a high water table have resulted in very poor geotechnical conditions. In addition, the soil and groundwater are impacted with contaminants related to historical industrial activity. Design and construction have taken into consideration constructability and long-term functionality associated with known environmental risks and the management of contaminated groundwater during and post-construction. Construction schedules required the construction of complex, diverse new soil horizons and planting of over 1 million plants in sequence with the heavy earth and civil works needed to excavate the valley. The presentation will focus on constructability

challenges and on the innovative design, construction and management solutions used to create 30 ha of new aquatic and terrestrial habitat in the middle of a highly urbanized downtown.

**Max B. Herzog**, Cleveland Water Alliance, Cleveland, OH, USA. **Lake Erie Volunteer Science Network: Engaging Communities with Credible Water Quality Data Collection.**

Volunteer science has immense potential to deepen our understanding of Lake Erie water resources. However, lack of standardized sampling methods as well as limited organizational visibility and credibility have often meant that their data is not considered in many decision-making processes. As a result, volunteer science groups have struggled to have their voices heard in water management, research, and advocacy. In 2020 a collaboration of community foundations and Cleveland Water Alliance (CWA) launched Lake Erie Volunteer Science Network (LEVSN) to unite our region's groups using three strategies: 1) Technical tools that empower individual volunteer groups to fill local data gaps, enabling them to effectively lead the identification and resolution of water quality issues in their communities. 2) A regional community of practice that allows volunteer groups to pilot new approaches, explore areas of shared interest, and pursue opportunities to advance their collective impact. 3) Regional standardization and coordination that aligns multiple groups into a credible volunteer science movement with a substantive voice in water governance processes. Since 2020, LEVSN participation has more than doubled and the network has partnered with key decision makers to work towards filling critical gaps and inform management efforts at the local, regional, and Great Lake levels. Now, as the three-year startup funding wraps up, it is time to institutionalize this network.

**Cecilia E Heuvel**[1], Aaron Fisk[2] and Yingming Zhao[3], [1]University of Windsor, Great Lakes Institute for Environmental Research, Windsor, ON, Canada, [2]School of the Environment, University of Windsor, Windsor, ON, Canada, [3]Aquatic Research and Monitoring Section, Ontario Ministry of Natural Resources and Forestry, Lake Erie Fishery Station, Wheatley, ON, Canada. **Moving targets: Quantifying resource consumption in mobile predators using stable isotopes.**

Stable isotopes are a tool often used to describe relationships between organisms within aquatic food webs. However, our ability to derive these relationships is dependant on species remaining within the study area for the duration of the study as isotope signatures of different resources vary spatially. For species that migrate or forage over wide areas, sampling efforts must capture the entirety of the species movement range to make inferences about resource consumption. Here, we will determine basin-specific differences in energy sources of Lake Erie fish with varying mobility (migratory: walleye, *Sander vitreus*; non-migratory: yellow perch, *Perca flavescens*) using stable isotopes of carbon ($\delta^{13}C$), nitrogen ($\delta^{15}N$), and sulphur ($\delta^{34}S$). We expect non-migratory species (yellow perch) to reflect the isotope signatures of the basin they were caught in, and migratory individuals (walleye) to have isotope values that reflect their migration range, which can be estimated from telemetry papers.

**Elizabeth K Hinchey Malloy**[1], Louis J. Blume[2], Ken Klewin[1] and Carole Braverman[2], [1]EPA GLNPO, Chicago, IL, USA, [2]EPA Region 5, Chicago, IL, USA. **Show me the data! Datasets collected and managed by the EPA Great Lakes National Program Office monitoring programs.**

The EPA Great Lakes National Program Office's (GLNPO) long-term monitoring programs constitute the longest-running, most extensive monitoring of water quality, lower trophic level biota, and contaminant levels in air, sediments and predator fish across all five Great Lakes by a U.S agency. GLNPO's long-term monitoring program data collection activities, in some cases spanning over four decades, are important for predicting ecosystem changes, understanding the dynamics of invasive species and how their effects may change with time, and developing improved management strategies to address chemical, physical and biological stressors. Proper management, reporting and dissemination of its vast data collection allows the GLNPO to effectively share meaningful and accurate information about the Great Lakes

ecosystem with the public. In this talk we will provide an overview of the datasets collected by the seven GLNPO monitoring programs. We will describe GLNPO's data management procedures and show how you can easily query and download data from these monitoring programs via EPA's Central Data Exchange Great Lakes Environmental Database. Other tools for accessing GLNPO data, including the EPA Science Hub at data.gov, will also be presented.

**Calvin Hitch**, **Alana McDonald** and Victoria Wisniewski, Toronto and Region Conservation Authority, Vaughan, ON, Canada. **The Toronto and Region Conservation Authority Water Quality Monitoring Network: a collaborative approach.**

The Toronto and Region Conservation Authority is tasked by partners and stakeholders with monitor and analyze water quality in the GTA jurisdiction for a variety of programs and initiatives. The entirety of the network boasts over 30 monitoring locations, all of which have been real-timed and are highly modular. The monitoring programs range from nutrient studies, chloride monitoring, load calculations, ongoing LID improvements and long term effects of climate change. The network utilizes many state of the art pieces of technology with telemetry, data management and custom programming; and the sandbox format has been accelerating research and collaboration in the Greater Toronto Area.

**Greg A Hitzroth**[1,2] and Katie O'Reilly[3], [1]Illinois Natural History Survey, Chicago, IL, USA, [2]Illinois-Indiana Sea Grant, Chicago, IL, USA, [3]Illinois-Indiana Sea Grant / Illinois Natural History Survey, Champaign, IL, USA. **Release Zero Retailer Program – Aquatic Invasive Species Education in the Aquarium Industry.**

Aquarium retailers have been identified as important sources of information about aquatic invasive species (AIS) prevention for aquarium hobbyists. In response to this finding, Illinois Natural History Survey and Illinois-Indiana Sea Grant (INHS/IISG) developed a state-wide Be A Hero - Release Zero organisms in trade (OIT) outreach campaign which promoted AIS prevention behaviors and was targeted at aquarium hobbyists. Campaign materials were developed for aquarium retailers to disseminate to their customers. Working to expand the campaign's footprint, INHS/IISG developed a Release Zero Retailer program to incentivize retailers to provide their customers with AIS outreach information as well as train their employees about AIS topics through online modules. This presentation will provide an overview of the Release Zero Retailer Program along with qualitative results and lessons learned from these efforts to inform other AIS outreach programs.

**Bogdan Hlevca**[1] and Edward Todd Howell[2], [1]Ontario Ministry of the Environment, Conservation and Parks, Toronto, ON, Canada, [2]Ministry of the Environment, Conservation and Parks, Toronto, ON, Canada. **Estimating nearshore-offshore water exchange in Lake Ontario.**

Lake Ontario's ecosystem comprises distinct nearshore and offshore trophic structures that are linked by hydrodynamic processes that transport water loaded with nutrients along and across the shore. The link to the algae growth to nuisance proportions and the scales over which these processes occur are not well understood. This study investigated the exchange between nearshore and offshore areas of Lake Ontario over two distinct periods during 2013 and 2018, using field monitoring and a three-dimensional numerical model. A virtual age-tracer was used to determine the horizontal mixing time scales between nearshore areas of the lake (water depth < 30 m), and offshore. A passive tracer released from eight locations around the model lake's perimeter showed that dispersal was more extensive in late summer, when stratification was established lake-wide, than during the mixed period. Water current speeds and mixing are shown to be correlated with wind and water temperature during the stratified season. Intrusions of hypolimnetic waters through upwelling events contribute to the net cross-shore transport and are most pronounced in May and June when the offshore thermocline is shallow. In the northern part of the lake dispersal was primarily alongshore, reflecting cyclonic (counterclockwise) coastal circulation during the

stratified season. In the western and southern parts of the lake, cross-shore mixing was enhanced by geomorphology induced cross-basin currents.

**Grant Hodgins**[1], Clare E. Robinson[1], James W. Roy[1,2] and Chris Power[1], [1]Department of Civil and Environmental Engineering, Western University, London, ON, Canada, [2]Water Science and Technology Directorate, Environment and Climate Change Canada, Burlington, ON, Canada. **Evaluating chloride exposure in the benthic zone of two urban streams.**

Increasing salinization of fresh surface waters due to elevated chloride (Cl) is threatening aquatic ecosystems across the Great Lakes Basin. Road de-icing salt is a major source of Cl to surface waters across the basin. Previous studies have shown that groundwater with elevated Cl is upwelling in some freshwater streambeds where it poses toxic effects to benthic species. The objective of this study was to evaluate the spatial and temporal exposure of the benthic zone to Cl due to the subsurface transport of road salt-derived Cl to freshwater streams. This was addressed through high resolution streambed monitoring along two ~100-m long urban stream reaches over 18 months. Streambed mapping showed high electrical conductivity (proxy for Cl) zones extending 30 – 60 m upstream and downstream of the major roads that intersect each stream. Cl concentrations in the benthic zone were found to range from 500 – 5000 mg/L, with 100% and 47% of all samples in these zones higher than chronic (120 mg/L) and acute toxicity guidelines (640 mg/L) for Cl. It was found that these high Cl zones typically extend across the entire width of the streams. Travelling further away from the roads the porewater Cl concentrations dropped to 50 – 300 mg/L. Cl exposure zones were found to be persistent year-round in both streams with Cl concentrations highest in the summer at some locations. This was supported by time-lapse electrical resistivity surveys at one of the streams showing a persistent year-round high conductivity subsurface plume traveling from a nearby parking lot and road to the stream.

Clare E. Robinson[1], **Grant Hodgins**[1], James W. Roy[1,2] and Chris Power[1], [1]Department of Civil and Environmental Engineering, Western University, London, ON, Canada, [2]Water Science and Technology Directorate, Environment and Climate Change Canada, Burlington, ON, Canada. **Characterizing shallow groundwater chloride near urban streams using geoelectric techniques.**

Chloride (Cl) concentrations in Lake Erie and Lake Ontario have been increasing since the early 1990s due to increased road salt de-icing application, landfill leachate, and wastewater sources entering freshwater streams. When trying to evaluate the different sources and pathways of Cl to these freshwater streams, one difficult pathway to characterize is groundwater storage and transport. This research evaluates the effectiveness of using electromagnetics (EM) and 2D and 3D direct current electrical resistivity tomography (ERT) to characterize groundwater chloride contamination travelling to a freshwater stream that has elevated Cl concentrations year-round. Both EM and 3D ERT surveys traced a high Cl plume from a nearby parking lot to the stream. While the EM survey was much faster (over 10 times faster) and able to rapidly cover more area, the ERT survey results best represent the groundwater Cl plume based on a comparison with groundwater sampling data. When comparing bulk conductivity measured by EM and ERT to measured groundwater Cl concentrations the $R^2$ value for EM and ERT were 0.57 and 0.82 respectively. ERT was also used to calculate the total mass of Cl in the groundwater plume, providing an assessment of groundwater Cl storage. 2D ERT time-lapse surveys were also used to evaluate temporal changes in the groundwater Cl plume with results showing the existence of the plume year-round with the stream receiving the highest groundwater Cl concentrations in the summer and fall.

**Josh Hoekwater**[1], Kelly Filer Robinson[2], Kevin Keeler[3], Sara Ang[1], Ralph W. Tingley III[3], Darryl Hondorp[3], John Janssen[4], Matthew Kornis[5] and Brian C. Weidel[6], [1]Michigan State University, East Lansing, MI, USA, [2]U.S. Geological Survey, Georgia Cooperative Fish and Wildlife Research Unit, Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA, USA, [3]USGS Great Lakes Science

Center, Ann Arbor, MI, USA, [4]University of Wisconsin-Milwaukee, Milwaukee, WI, USA, [5]U.S. Fish and Wildlife Service, Green Bay Fish and Wildlife Conservation Office, Green Bay, WI, USA, [6]USGS Great Lakes Science Center, Oswego, NY, USA. **Competition between Round Goby and Slimy Sculpin in a Laboratory Setting.**

Slimy Sculpin populations have dramatically declined in many of the Great Lakes coincident to invasive Round Goby increasing in abundance. One hypothesis for the decline is that the Round Goby is outcompeting Slimy Sculpin for spawning habitat and feeding opportunities. However, behavioral interactions between these species have never directly been observed, and other coincident ecosystem changes in the Great Lakes could also contribute to Slimy Sculpin declines (e.g., increases in dreissenid mussel abundance and decreases in *Diporeia*). Our work informs this knowledge gap within a laboratory setting by comparing spawning success, aggressive behavior, artificial spawning shelter occupancy, and growth of Slimy Sculpin pairs when Round Goby are present or absent. We maintained 20 tanks at 4–6°C for one to two months and analyzed video footage of Slimy Sculpin pairs utilizing artificial spawning shelters in the presence or absence of Round Goby. Preliminary results indicate that interactions between these two species may not be as one-sided as previously hypothesized, but the threat of larger gobies displacing Slimy Sculpins from shelter could affect their spawning success.

**Courtney Holden**[1], **Kayla Sunday**[2], Britney Bourdages[2], Matthew JS Windle[1], Stephany Hildebrand[1], Emma Bacchiochi[1] and Travis Cole[2], [1]St. Lawrence River Institute, Cornwall, ON, Canada, [2]Mohawk Council of Akwesasne, Akwesasne, ON, Canada. **Monitoring dam impacts on migratory fish using visual survey methods founded on mutual respect and autonomy.**

Tailwater surveys are conducted annually below dams to record impacts on migrating fish populations, but predominantly target dead fish that float and wash ashore. Recent community observations of large numbers of dead, moribund or lethargic American eels at the bottom of the St Lawrence River below the Moses-Saunders Power Dam revealed that some eels may go undetected by current survey methods. This highlighted the need for innovative and rapidly deployed, non-invasive approaches to supplement existing survey methods. It also emphasized the importance of using a unified approach that strengthens partnerships to address shared ecological concerns, including the preservation and management of SAR. In November 2022, staff from two organizations (Indigenous and non-Indigenous) collaborated to conduct weekly drone surveys in parallel with visual boat surveys using standardized transects to count inactive eels at the bottom of the river. Both methods showed parallel trends in the number of eels observed between weeks. Boat surveys had the advantage of detecting fish in deeper water and more inclement weather, while drone flights took less time and fewer resources to complete and could more easily survey shallow (<1 m depth), rocky areas. This combined methodology approach shows promise for improving the detection rate of eels and other species similarly affected by dams. The survey work was also founded on mutual respect, autonomy, and sovereignty and future activities will further explore the use of traditional methodologies in parallel with these visual methods.

**Anna Li Holey**, Saumik Mallik and Pengfei Xue, Michigan Technological University, Houghton, MI, USA. **Joint Probability Analysis of Extreme Precipitation and Water Level for Chicago, Illinois.**

A compound flooding event occurs when there are a combination of two or more extreme factors that happen simultaneously and cause flooding. In the Great Lakes Region, it is common for a compound flooding event to occur with a high lake water level and heavy rainfall. With the potential of increasing water levels and an increase in precipitation under climate change, the Great Lakes' coastal regions could be at risk for more frequent and severe flooding. The City of Chicago which is located on Lake Michigan has a high population and dense infrastructure and is very vulnerable to a compound flooding event, even with the implementation of its water control structures. For this case study, annual maximum precipitation and corresponding lake water level data were analyzed to examine the bivariate return period of a compound flood event using a copula function. The results show that under climate change if the water level were to

rise by 0.2, 0.45, or 0.8 m, compound flooding events due to heavy precipitation and high water level will be more likely in the future. By documenting the joint risk of potential compound flooding in this area, preventative measures and planning can be implemented.

**Yi Hong**[1], Lauren M Fry[2], Sophie Orendorf[1], James Kessler[2] and Andrew Gronewold[3], [1]Cooperative Institute for Great Lakes Research, Ann Arbor, MI, USA, [2]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, USA, [3]University of Michigan, Ann Arbor, MI, USA. **Operational forecasting of net basin supply for the Great Lakes: A combination of NMME and NWM.**

Accurate water supply predictions are critical for robust water resources management. Over the past decades, multiple operational modeling tools and datasets have been employed to address this need. However, the net basin supply (NBS) forecasting for the Great Lakes remains challenging due to international boundaries and sparse ground gauge observations. In this context, this study aims to assess the potential for operational NBS forecasting by combining the North American Multi-Model Ensemble (NMME) and National Water Model (NWM). Specifically, daily precipitation and evaporation over the lakes are obtained by analyzing different models of NMME, runoff into the lakes is calculated by aggregating contributing streamflows of NWM. The NBS is hence equal to the precipitation plus the runoffs, and minus the evaporation. Analysis was performed for 2012 – 2020 that operational NWM and NMME outputs are publicly available. Models were first evaluated by comparing precipitation, evaporation, and runoff with the Large Lake Statistical Water Balance Model (L2SWBM), which takes a probabilistic approach to estimate the 95% credible interval of these components in the context of closing the water balance. NBS was then compared with the residual net basin supply, which is equal to the change in storage minus inflows to each lake through connecting channels, and plus outflows. Results of this study indicate the performance of operational NBS forecasting with NMME and NWM, which facilitate the development of new forecasting tools for water level management of the Great Lakes.

**Andrew E. Honsey**[1], Ralph W. Tingley III[2], Katie Anweiler[3], Cory Brant[2], David B. Bunnell[2], Marc Chalupnicki[4], Chris Davis[5], Paul Fedorowicz[2], Dimitry Gorsky[6], Todd Hayden[1], Matthew E Herbert[7], Philippa Kohn[8], Brian O'Malley[9] and Jason Smith[10], [1]USGS Great Lakes Science Center, Millersburg, MI, USA, [2]USGS Great Lakes Science Center, Ann Arbor, MI, USA, [3]Michigan State University and USGS Great Lakes Science Center, Ann Arbor, MI, USA, [4]USGS Great Lakes Science Center, Cortland, NY, USA, [5]Ontario Ministry of Natural Resources and Forestry, Owen Sound, ON, Canada, [6]US Fish and Wildlife Service, Basom, NY, USA, [7]The Nature Conservancy, Shepherd, MI, USA, [8]The Nature Conservancy, Rochester, NY, USA, [9]USGS Great Lakes Science Center, Oswego, NY, USA, [10]Sault Ste. Marie Tribe of Chippewa Indians, Sault Ste. Marie, MI, USA. **Documentation of a probable spawning run of Cisco *Coregonus artedi* in the Spanish River, Ontario, Canada.**

Cisco (*Coregonus artedi*) were once among the most ecologically, economically, and culturally important fishes in the Great Lakes, but they declined dramatically throughout the 19th and 20th centuries. In response to this decline and to promote resilient and sustainable fisheries, managers have prioritized the restoration of Cisco and other coregonines in the Great Lakes. An important component of fish restoration and conservation efforts is identifying spawning habitats and the potentially distinct populations that use them. Historical accounts indicate that Cisco spawned in Great Lakes tributaries, but the contemporary extent and nature of tributary spawning by Cisco is largely unknown. We sampled 31 Cisco from a probable spawning run on 14-16 November 2022 via boat electrofishing in the Spanish River (Ontario, Canada) just downstream of the Espanola Dam, roughly 52 km upstream of the mouth in the North Channel of Lake Huron. We describe the demographics, gonad condition, and morphometrics of this sample, and we compare our results to those of other Lake Huron Cisco populations. To our knowledge, these findings represent the best evidence of Cisco spawning in a Great Lakes tributary since the late 1800s, and they have important implications for coregonine conservation and restoration across the basin.

**Kaitlyn Horton**[1] and Andrea E. Kirkwood[2], [1]Ontario Tech University, Oshawa, ON, Canada, [2]Faculty of Science, Ontario Tech University, Oshawa, ON, Canada. **The role of stormwater management ponds in regulating chloride fate in urban sewersheds.**

Stormwater Management Ponds (SWMPs) are important in flood management and sedimentation of stormwater debris prior to discharge into receiving waters. Chloride is a common contaminant in urban stormwater due to the broad-scale application of chloride-laden de-icers in temperate regions. As part of a larger study investigating the regulation of water quality by SWMPs, we measured chloride concentrations at the inflow, permanent pool, and outflow locations of 12 SWMPs varying in age and size in Oshawa, Ontario from June – September, 2022. Our results showed persistently high chloride concentrations over the course of the study period, where median inflowing chloride levels were higher than outflowing levels, but there was a high degree of variability. In particular, we found that chloride decreased following storm events, which potentially indicates a dilution effect. The high chloride concentrations being discharged are of concern because they exceed the current water quality guidelines for aquatic organisms. Most interesting was that the lowest chloride concentrations were typically found in the permanent-pool locations. Overall, these results show that SWMPs mediate chloride concentrations prior to discharge, and thus play a role in chloride fate and dynamics in urban areas.

Mei Zhang, Minmin Niu and **Xiuli Hou**, College of Agronomy and Life Sciences, Kunming University, Kunming, China. **The Mutual Inhibition between Submerged Macrophytes with Different Planting Density and *Microcystis aeruginosa* .**

Submerged macrophytes can inhibit cyanobacteria bloom, which are dominated by *Microcystis aeruginosa*. The inhibitory effect of submerged macrophytes on *M. aeruginosa* depends on its density. The dialysis bag method was used to form the co-culture system between *Vallisneria natans (Lour.) Hara* with three density 1000g/m$^3$, 1500g/m$^3$ and 2000g/m$^3$ and *M. aeruginosa with* $4\times10^5$cell/ml. The results showed that the OD of *M. aeruginosa* in three co-culture groups decreased by 18.58%, 42.24% and 27.77%, the content of chlorophyll *a* decreased by 49.68%, 60.24% and 50.14%, and the photosynthetic activity decreased by 13.53%, 25.71% and 16.82%, respectively. These results indicated that the planting density of 1500g/m$^3$ *V. natans (Lour.) Hara* had stronger inhibition effect on the density, chlorophyll *a* and photosynthetic activity of *M. aeruginosa* than other planting densities. And the Phycobilin (phycocyanin, allophycocyanin and phycoerythrin) of *M. aeruginosa* reduced in three co-culture group of *M. aeruginosa and V. natans (Lour.) Hara*. In three co-culture groups, the chlorophyll *a* content, photosynthetic activity, the photosynthetic quantum yield of *V. natans (Lour.) Hara* increased. In co-culture groups of *M. aeruginosa and V. natans (Lour.) Hara* with the planting density of 1500g/m$^3$ and 2000g/m$^3$, *V. natans (Lour.) Hara* fresh weight increased by 18.91% and 58.92% respectively. Therefore, the planting density of *V. natans (Lour.) Hara* (1500g/m$^3$) can effectively inhibit *M. aeruginosa* by reducing chlorophyll *a*, photosynthetic activity and Phycobilin of it.

**Alexandria G. Hounshell**[1], Laura T. Johnson[2] and Richard Stumpf[3], [1]National Centers for Coastal Ocean Science, NOAA, Beaufort, NC, USA, [2]Heidelberg University NCWQR, Tiffin, OH, USA, [3]NOAA, Silver Spring, MD, USA. **Nutrient and environmental factors regulating western Lake Erie cyanobacterial blooms.**

Recurring summer cyanobacterial blooms in Western Lake Erie have severe negative impacts on human, animal, and ecological health. Strong correlations between spring (March-July) phosphorus loading from the Maumee River, the largest freshwater and nutrient load contributor to western Lake Erie, and annual cyanobacterial bloom severity have been used to predict upcoming summer bloom severity. The spring phosphorus load, however, does not explain all the variation in bloom severity. Thus, considering additional environmental and nutrient parameters may help to better constrain physical and biogeochemical processes that regulate seasonal bloom severity, leading to more accurate summer cyanobacterial predictions. To identify key predictors for annual cyanobacterial bloom severity we aggregated various

environmental parameters, such as: nitrogen and phosphorus loading from the Maumee River, seasonal surface water temperature, and winter ice maxima from 2003-2022. Empirical model results confirm that spring phosphorus loading, as total bioavailable phosphorus, from the Maumee River is still the dominant environmental factor controlling cyanobacterial blooms in western Lake Erie. Additional environmental factors, however, like winter and/or spring temperature, are likely important in modulating bloom severity. Thus, incorporating other environmental parameters, in addition to Maumee River spring phosphorus loading should improve seasonal predictions of cyanobacterial bloom intensity in the future.

**Kelly Hoyer**[1], Andrew Scott McNaught[1], Jory L. Jonas[2], Jason Smith[3], Tracy L Galarowicz[1] and J. Ellen Marsden[4], [1]Central Michigan University, Mount Pleasant, MI, USA, [2]Michigan Department of Natural Resources, Charleviox, MI, USA, [3]Sault Ste. Marie Tribe of Chippewa Indians, Sault Ste. Marie, MI, USA, [4]University of Vermont, Burlington, VT, USA. **Diet assessment and growth of larval *Coregonus clupeaformis* and *C. artedi* in the Upper Great Lakes.**

In 2011, resurgence of Cisco occurred in northern Lake Michigan while Lake Whitefish populations have continued to decline. Recruitment bottlenecks for Lake Whitefish at the larval or juvenile stage may be driven by poor growth resulting from low prey densities in nearshore areas. We used age-length regressions to compare growth in larval Lake Whitefish and Cisco collected in 2019 and 2021 from northern Lake Michigan-Huron sites, assessed diets, and related growth and diet to prey density and composition. We also experimentally investigated foraging capabilities of the two species at three different sizes (13-18 mm, 25-30 mm, and 43-48 mm) using four different prey species (cyclopoid copepods, *Bosmina spp,* chironomid larvae, and *Artemia* nauplii). In the field, Cisco consumed smaller prey items than Lake Whitefish yet exhibited higher growth rates. Lake Whitefish consumed higher quantities of *Bosmina* than Cisco. In the lab, Lake Whitefish had higher capture rates of *Bosmina* than Cisco; however, large Cisco had higher capture rates of cyclopoids than large Lake Whitefish. *Bosmina* were found in low abundance in nearshore sites, whereas cyclopoids were found in higher abundance (though total zooplankton density was low). These findings suggest that as Lake Whitefish and Cisco grow beyond 40 mm in length, Cisco are more successful than Lake Whitefish foraging on cyclopoids which are relatively more abundant than *Bosmina.*

**Chenfu Huang**[1], Miraj Kayastha[1], Pengfei Xue[1], Jiali Wang[2], Zhao Yang[3], William Pringle[2], TC Chakraborty[3], Yun Qian[3] and Robert D. Hetland[3], [1]Michigan Technological University, Houghton, MI, USA, [2]Environmental Science Division, Argonne National Laboratory, Lemont, IL, USA, [3]Pacific Northwest National Laboratory, Richland, WA, USA. **Lake-Atmosphere Feedbacks Intensify the Summer Warming of the Great Lakes.**

The Laurentian Great Lakes have been increasingly experiencing climatic, hydrological, and ecological changes. An accurate mechanistic representation of the Great Lakes thermal structure in Regional Climate Models (RCMs) is paramount to study the climate of this region. Currently, RCMs have primarily represented the Great Lakes through coupled one-dimensional lake models which are unable to resolve the realistic hydrodynamics of the Great Lakes and lead to inaccurate representations of lake surface temperature (LST) that influence regional climate patterns. This work has developed a fully two-way coupled modeling system using the Weather Research and Forecasting (WRF) model and a three-dimensional hydrodynamic model to represent more realistic hydrodynamics and the lake-atmosphere interactions. The system is then validated and used to investigate the potential impacts of lake atmosphere coupling on the simulated summer LST of Lake Superior. By evaluating the difference between our coupled modeling system and observation-driven modeling system, we found that coupled lake atmosphere dynamics can lead to a higher LST during June-September through higher net surface heat flux inflow in June and July and a lower net surface heat flux inflow in August and September. The unstratified water in June distributes the entering surface heat flux throughout the water column leading to a minor LST increase; in contrast, the stratified waters of July create a conducive thermal structure for the water surface to warm rapidly under the higher incoming surface heat flux.

**Justin Hubbard**[1], Andrew Drake[2] and Nicholas E. Mandrak[3,4], [1]Department of Physical and Environmental Sciences, University of Toronto Scarborough, Scarborough, ON, Canada, [2]Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries and Oceans Canada, Burlington, ON, Canada, [3]Department of Biological Sciences, University of Toronto Scarborough, Toronto, ON, Canada, [4]Department of Physical and Environmental Sciences, University of Toronto Scarborough, Toronto, ON, Canada. **Estimating global sources and secondary spread of freshwater invasions to the Great Lakes basin under climate change.**

We employed a climate-matching method to evaluate potential source regions of freshwater invasive species to an introduced region, the Laurentian Great Lakes ecoregion, and their potential secondary spread, under historical and future climates. We conducted a climate-match analysis to estimate global source freshwater ecoregions under historical and future climates with an ensemble of general circulation models for climate-change scenario SSP5-8.5. We then estimated the potential secondary spread of freshwater invaders to other ecoregions of North America under historical and future climates. We identified 54 global freshwater ecoregions with a climate match ≥ 71.7 % to the recipient Great Lakes ecoregion under historical climatic conditions and 11 additional ecoregions were predicted to exceed the threshold under climate change. Three of the 11 ecoregions were located in South America, where no matches existed under historical climates and eight were in the southern United States, southern Europe, Japan, and New Zealand. Further, we identify 34 North American ecoregions of potential secondary spread of freshwater invasions from the Great Lakes under historical climatic conditions, and five more ecoregions predicted to exceed the threshold under climate change. The identified ecoregions are candidates for detailed biosecurity risk assessments and related management actions.

**Eric Huber**, Kristen Towne, Janine Lajavic and Gregory Wright, U.S. Fish & Wildlife Service, Alpena, MI, USA. **Facilitating success: Adaptations made over ten years of early detection and monitoring in western Lake Erie.**

Despite increased regulations to minimize aquatic invasive species (AIS) introductions into the Laurentian Great Lakes, there remains a need to monitor for and detect new species before they establish. Included in Annex 6 of the Great Lakes Water Quality Agreement (2012) is the task to develop and implement an early detection and monitoring (EDM) initiative that identifies priority locations and monitoring protocols for surveillance. Given the need to capture a wide variety of fish species occupying all available niches, adaptation is a key component of EDM program success. This presentation describes the changes made to increase the efficiency of the U.S. Fish & Wildlife Service (USFWS) Alpena, MI field office EDM Program in the Lake Erie basin from 2013–22. Changes include (a) an increase in sampling locations, (b) optimizing gear allocation, (c) increased crew days and effort, and (d) a transition from random to targeted sampling. These changes increased rare species and contemporary species captures from 10% and 50% respectively in 2013 to 80% and 75% captured in 2022. Success in this program is demonstrated by captures of invasive Redear Sunfish (*Lepomis microlophus*) in previously undocumented waters and Nile Tilapia (*Oreochromis niloticus*) likely released from aquaculture sources. The USFWS EDM program will continue to adapt into the future to maximize capture efficiencies and successfully monitor Lake Erie for new threats of invasion.

**Len M. Hunt** and Mallory Wiebe, Ontario Ministry of Natural Resources and Forestry, Thunder Bay, ON, Canada. **Understanding the diversity of Ontario's Great Lakes recreational fishery.**

Recreational fishing on and around the Great Lakes is an important social and economic activity. These lakes and their connected waters and tributaries provide a diverse set of opportunities for recreational fishers. This diversity can help build a resilient Great Lakes fishery that is better able to handle social and ecological changes to fish communities and fishers. Drawing data and information from large-scale surveys of recreational fishers in Ontario, Canada, we first describe the diverse types of recreational fisheries that exist across Ontario's Great Lakes. This description focuses on recreational fishers (e.g., their origins),

fishing activity (e.g., fishing activity targeted on different species), and outcomes of fishing (e.g., catch and harvest of different species). Second, we assess the temporal stability of these and other patterns in the recreational fishery. Finally, we provide insights into how plausible future scenarios (e.g., human population change) might impact the future of recreational fishing on the Great Lakes.

**Ryan Hutchins** and Stefania Impellizzeri, Toronto Metropolitan University, Toronto, ON, Canada.
**Greener Ice with Cleaner and Recycled Water: Improving Water Quality and Reducing the Carbon Footprint of Arenas.**

The Great Lakes watershed is home to over 1000 ice arenas, making it a significant user of water resources. The water-energy nexus is a crucial consideration in the operation of these arenas, as the production of ice requires significant energy inputs. While the importance of implementing best practices in water use and management is clear, the impact of water quality on ice quality has yet to be thoroughly examined. This study aims to investigate the dissolved solids, gases and water treatments required for optimal ice production. Our future work will involve investigating these issues, as well as emerging contaminants, microplastics, and exploring new technologies in ice arena water management. The overall goal of this research is to provide valuable insights for the responsible and sustainable operation of ice arenas in the Great Lakes watershed and beyond.

**Abby Hutson**[1], Ayumi Fujisaki-Manome[2] and Brent M Lofgren[3], [1]CIGLR, University of Michigan, Ann Arbor, MI, USA, [2]Cooperative Institute for Great Lakes Research, University of Michigan, Ann Arbor, MI, USA, [3]formerl of NOAA/GLERL, Ann Arbor, MI, USA. **Testing Sensitivity of A Great Lakes Regional Climate Model with a 1-D Lake Model.**

The Weather Research and Forecasting (WRF) model is used to dynamically downscale ERA-Interim global reanalysis data to test its performance as a regional climate model (RCM) for the Great Lakes Region (GLR). With the primary goal of correctly simulating precipitation accumulation within the Great Lakes Drainage Basin (GLDB), four cumulus parameterizations are used in conjunction with three moisture nudging techniques. Sensitivity of simulated air temperature and lake-surface temperature (LST) is also evaluated by varying the one-dimensional WRF-Lake model version and initialization. While all RCM simulations have a dry bias in the summer, scale-aware cumulus parameterizations perform the best, even outperforming the ERA-Interim reanalysis in annual precipitation. Moisture nudging does not play an important role in climate-scale precipitation accumulation. The RCM has a cold bias in 2 m temperature, particularly in the winter, but improving the WRF-Lake model with a dynamic albedo and initializing with a constant 4 degC LST alleviates the bias.

**Edina Illyes**[1] and Nicholas E. Mandrak[2], [1]University of Toronto Scarborough, Toronto, ON, Canada, [2]Department of Physical and Environmental Sciences, University of Toronto Scarborough, Toronto, ON, Canada. **Contemporary lacustrine fish communities in the Lake Agassiz basin: Legacy of a glacial lake.**

Changes in climate can alter species' distributions and ranges and, in extreme cases, such as during continental glacial cycles, can result in latitudinal shifts of entire biomes. Freshwater fishes are especially vulnerable during such shifts because they rely on the presence of suitable lentic and lotic systems for dispersal and colonization. We examined the effects differential contact to the dispersal corridor of glacial Lake Agassiz had on the contemporary lacustrine fish communities of northwestern Ontario during the Wisconsinan deglaciation. Compositional dissimilarity increases with pair-wise differences in lake age, driven by turnover and nestedness and, in lakes outside of the spatial extent of Lake Agassiz, species composition

is positively correlated with elevation. These patterns indicate variation in species present during the colonization process, likely driven by paleoenvironments of the glacial lake and dispersal abilities of species. Our study shows that postglacial colonization influenced contemporary lacustrine fish communities within the same geographical region. It underscores the importance of understanding the effects of historical drivers on contemporary assemblages, which can have implications for freshwater fish dispersal to suitable climatic conditions in the future, particularly in the absence of extensive freshwater connections such as those of the last glacial retreat.

**Jessica Ives**[1,2], Stephanie J Guildford[3], Achieng Alfred Otieno[4], Ted J Lawrence[5], Lars G. Rudstam[6] and Orlane Anneville[7], [1]Great Lakes Fishery Commission, Ann Arbor, MI, USA, [2]International Association for Great Lakes Research, Ann Arbor, MI, USA, [3]Journal of Great Lakes Research, Kitchener, ON, Canada, [4]University of Eldoret, Eldoret, Kenya, [5]International Institute for Sustainable Development, Winnipeg, MB, Canada, [6]Cornell Biological Field Station, Bridgeport, NY, USA, [7]INRA, Thonon-les-Bains, France. **International aspects of the International Association for Great Lakes Research and Journal of Great Lakes Research.**

The International Association for Great Lakes Research's (IAGLR) mission is to advance understanding of the world's great lake ecosystems. However, most of the activities of IAGLR have historically concentrated on the North American Laurentian Great Lakes with most of its members and virtually all its Board of Directors coming from Canada and USA. In 2018, IAGLR made a step to strengthen its role as an international association for great lakes research by expanding its board to include one member from outside USA and Canada (specifically phrased to allow direct representation from Indigenous Nations within North America). In 2019, the International Committee was formed and given responsibility for enhancing the international activities of the association. Efforts to increase international engagement include participation in a joint European Large Lakes Symposium-IAGLR meeting in France, additional international Associate Editors for the Journal of Great Lakes Research (JGLR) and internationally focused special sections of JGLR. In this poster we examine some of the long term trends in IAGLR and JGLR's international efforts, highlight recent activities of the International Committee, and explore opportunities for future efforts. We will use a survey to solicit direct input from the IAGLR membership on the activities of the committee and how to improve IAGLR's international efforts moving forward.

# J

**Mehriban Jafarova**[1], Julian Aherne[2] and Stefano Loppi[1], [1]University of Siena, Siena, Italy, [2]Trent University, Peterborough, ON, Canada. **Deposition of airborne microplastics by moss biomonitoring: a case study from Tuscany, Central Italy.**

Despite the vast literature showing that microplastic (MP, i.e., plastic particles <5 mm) contamination is ubiquitous in marine and coastal environments, there are limited studies of the atmospheric deposition of MPs. There is evidence that moss and lichen, which are well known for their ability to accumulate airborne pollutants such as potentially toxic elements, can be profitably used for assessing the atmospheric deposition of microplastics (Roblin, B. & Aherne, J 2020; Loppi et al., 2021; Jafarova et al., 2022). In this study, moss samples were collected from 33 remote sites in Tuscany, Central Italy, digested by wet peroxide oxidation and examined under a stereomicroscope for MPs based on the hot needle test and other standard criteria used in similar studies. Further, the deposition rate of MPs was calculated based on the mass/area ratio. The results of the study showed MPs in the range of 12–64 MP/g dw, with fairly similar values across sampling sites. These values are comparable or even slightly higher than those from similar studies carried out in remote areas of Italy (13–27 MP/g dw) and Ireland (15–30 MP/g dw), thus suggesting long-range atmospheric transport. It was concluded that moss can be effectively used

for large-scale biomonitoring of the deposition of airborne MPs. The presence of MPs at all the remote sites highlighted the potential human exposure even in areas far from urbanisation.

**Henry Lewis James**[1,2], Jonathan Ruppert[1,2], Lyndsay Cartwright[1], Andrea Chreston[1] and Marie-Josée Fortin[2], [1]Toronto and Region Conservation Authority, Vaughan, ON, Canada, [2]Department of Ecology and Evolutionary Biology, University of Toronto, Toronto, ON, Canada. **Responses of migratory passerine species to restoration of stopover habitat in an urban park.**

Declines in migratory bird populations across North America highlight the urgency to protect and restore stopover habitat, where migrating birds rest and refuel, to facilitate annual movement between breeding and wintering grounds. After years of natural succession and habitat restoration at Tommy Thompson Park (TTP) in Toronto, the once barren, constructed landform is now a Key Biodiversity Area and Environmentally Significant Area that supports hundreds of bird species. Bird diversity at TTP peaks during migration, suggesting its potential to support stopover. Using 20 years of bird banding data (2003-2022) collected at the TTP Bird Research Station, we investigate temporal changes to migratory passerine communities in the park in relation to restoration efforts. Using regression analyses, rank-abundance curves, and clustering techniques, we identified: 1) temporal changes in migratory passerine diversity; 2) differences in community structure between and within seasons; and 3) species that drive community change. Comparing these results to the type and area of habitat restored over time allows us to identify measures that can help to improve stopover habitat quality. Our results provide insight into how restoring urban spaces may support passerine migration and help guide ecosystem management that supports migratory stopover.

**Aisha Javed**, Casey Loudoun, Alex Neumann, Carlos Alberto Arnillas and George B. Arhonditsis, Ecological Modeling Laboratory, Department of Physical and Environmental Sciences, University of Toronto, Toronto, ON, Canada. **Long-term phosphorus loading trend analysis in the Bay of Quinte, Ontario.**

The Bay of Quinte (BoQ), a picturesque Z-shaped embayment located on the northeastern shore of Lake Ontario, is a top destination for boaters and anglers. Excessive inputs of nutrients, primarily phosphorus (P), have impaired the Bay's water quality through the presence of frequent and spatially extensive algal blooms, hypolimnetic oxygen depletion, and predominance of toxic cyanobacteria. My work with quantifying the historical and on-going total phosphorus (TP) loading trends from the major five tributaries (Trent River, TR; Moira River, MR; Salmon River, SR; Napanee River, NR; and Wilton Creek, WC) in the BoQ reveals that while a significant decline in the riverine TP levels was observed during the 1980s and 1990s, not only exceedingly high concentrations (>100-150 $\mu g\ L^{-1}$) can still registered in the local tributaries, but also the TR, NR, and WC undergo frequent violations (45-60%) of the threshold level of 20 $\mu g\ TP\ L^{-1}$. Moreover, my recent work with forcing the Soil and Water Assessment Tool (SWAT) with GCM inputs to predict near- (2019-2059) and distant- (2060-2100) future streamflow in NR and WC suggests an earlier occurrence of spring freshet and more intense summertime precipitation events in the future that may result in changes in the timing of exogenous nutrient masses into the BoQ and may increase the susceptibility of the BofQ to undesirable shifts in water quality conditions. The findings from this current research are anticipated to assist in guiding the long-term phosphorus management strategy in the BoQ area.

**Christopher J. Jobity**[1], James W. Roy[1,2], Thomas A. Edge[3], Evan A. Angus[4] and Clare E. Robinson[1], [1]Department of Civil and Environmental Engineering, Western University, London, ON, Canada, [2]Water Science and Technology Directorate, Environment and Climate Change Canada, Burlington, ON, Canada, [3]Department of Biology, McMaster University, Hamilton, ON, Canada, [4]Department of Civil and Environmental Engineering, University of Western Ontario, London, ON, Canada. **Determining Pathways Via Which Septic System Wastewater Effluent Reaches Tributaries.**

Septic systems are widely used across the Great Lakes Basin in areas not serviced by a centralized wastewater treatment plant. Various pollutants in septic wastewater effluent (e.g., nutrients, faecal contaminants, emerging contaminants) may be transported to streams, but the amount delivered depends on the pathways delivering the septic wastewater to the stream (e.g., groundwater including capture in tile drains, overland runoff, illegal direct pipes). The objective of this study was to evaluate the use of different field tracer approaches to determine the amount of septic wastewater reaching streams and the various contributing pathways. To achieve this objective, artificial sweeteners (acesulfame, saccharin, cyclamate, sucralose), E. coli, and microbial DNA markers (HF183 and human mitochondrial markers) were used as tracers for septic wastewater in four streams in the Lake Erie Basin. High resolution longitudinal stream surveys were combined with high frequency event-based sampling and analysis of stream concentration-discharge (C-Q) relationships. The data indicate the utility of these combined approaches for analyzing the pathways via which the effluent is reaching the stream, including identifying locations where septic wastewater is delivered to the stream via direct (illegal) connections. The findings from this study provide information needed for contaminant (including nutrient) load calculations and making science-informed decisions regarding septic system regulations, including inspection and maintenance programs.

**Emily Johnson**[1], Timothy Hoellein[1], Raul Lazcano[1], Scott Higgins[2], Diane Orihel[3], Michael Rennie[4], Matthew Hoffman[5], Michael Paterson[2], Jennifer Provencher[6] and Chelsea Rochman[7], [1]Loyola University Chicago, Chicago, IL, USA, [2]International Institute for Sustainable Development Experimental Lakes Area, Winnipeg, MB, Canada, [3]Queens University, Kingston, ON, Canada, [4]Lakehead University, Thunder Bay, ON, Canada, [5]Rochester Institute of Technology, Rochester, NY, USA, [6]Environment and Climate Change Canada, Ottawa, ON, Canada, [7]University of Toronto, Toronto, ON, Canada. **Microplastic addition to littoral lake mesocosms: Impacts on ecosystem processes.**

Studies on the ecological effects of microplastics (i.e., particles <5mm) is a quickly growing field. In aquatic environments, biofilms are food sources, conduct critical element transformations, and colonize microplastics. However, few studies have examined the effect of microplastics on ecosystem processes like primary production, respiration, and nitrogen gas ($N_2$) fluxes. In June 2022, at the IISD-Experimental Lakes Area, Canada, we added microplastics spanning a gradient of concentrations to littoral mesocosms (N=9), in-lake enclosures that were 2 meters wide, 1.2 meters deep, and open to the sediment at the bottom to help simulate real-world conditions and capture sediment interactions. We recorded dissolved oxygen, temperature, wind speed, and light every 15 minutes from June-August in all mesocosms and in the lake epilimnion. During a 24-hour period in July, we manually collected dissolved $N_2$ samples hourly. Metabolism and gas flux metrics will be calculated using the LakeMetabolizer package in R. We predict microplastic will provide more surface area for biofilms, thereby increasing metabolism and $N_2$ flux. Although, we expect rates will be low overall due to oligotrophic conditions. These data will be integrated with suite of data on community and organismal metrics, generating unique insights on ecosystem-scale effects of microplastics in lakes.

**Olivia F Johnson**[1], Raissa Mendonca[1], Richard Becker[2], Thomas Bridgeman[3], Kennedy Doro[2], Justin D Chaffin[4], Kristen DeVanna Fussell[5], Stephen Jacquemin[6], Laura T. Johnson[7], Janice Kerns[8], Ganming Liu[9], Kevin McCluney[9], Helen Michaels[9], W. Robert Midden[9], Silvia E Newell[10], Christopher J Winslow[5], Nicole Wright[5] and Lauren Kinsman-Costello[1], [1]Kent State University, Kent, OH, USA, [2]University of Toledo, Toledo, OH, USA, [3]Lake Erie Center, University of Toledo, Toledo, OH, USA, [4]The Ohio State University, Put-In-Bay, OH, USA, [5]Ohio Sea Grant & Stone Laboratory, Columbus, OH, USA, [6]Wright State University- Lake Campus, Celina, OH, USA, [7]Heidelberg University NCWQR, Tiffin, OH, USA, [8]ODNR - Old Woman Creek NERR, Huron, OH, USA, [9]Bowling Green State University, Bowling Green, OH, USA, [10]Wright State University, Dayton, OH, USA. **Developing a new program for monitoring the nutrient function of restored wetlands in Ohio.**

Edge-of-field and marginal land wetlands are often restored or created with the goal to reduce excess nutrient export to downstream waters. It remains challenging to assess water-quality related function of wetlands in human-altered landscapes due to scientific uncertainty in ecosystem processes and variation in management decisions. The H2Ohio Wetland Monitoring Program mobilizes a team of interdisciplinary university researchers across Ohio to investigate the effectiveness of state agency-funded wetland projects. Since 2020, the H2Ohio initiative has initiated >100 wetland restoration projects, many of which are in agricultural watersheds. Projects range from 0.5 to 1,000 acres, across 43 counties, providing an unprecedented opportunity to track soil, water, and plant nutrients in young wetlands across spatial scales and hydrologic regimes. We will outline the team science and data collection structures created by the Monitoring Program. Numerous logistical lessons and scientific frameworks have been rapidly fostered by preliminary characterization and routine sampling of >40 wetland projects. Ultimately, sustained working relationships with project managers, property owners, and other partners are vital for researchers to capture practically-relevant conditions and assess the impact of wetland design and management decisions.

**Peter Johnson**, Great Lakes St. Lawrence Governors & Premiers, Arlington Heights, IL, USA.
**Management Planning in the Great Lakes-St. Lawrence River Basin.**

The Great Lakes St. Lawrence Governors (GSGP) serves as the Secretariat to the Great Lakes-St. Lawrence River Basin Water Resources Council (Compact Council) and the Great Lakes St. Lawrence River water Resources Regional Body (Regional Body). In that role, the GSGP provides support to the Governors' and Premiers' alternates as they work together on identifying research priorities and implement management plans based on that research. This presentation will provide an overview of that work, including on the comprehensive Cumulative Impact Assessment that is required under the terms of the Great Lakes Agreement and Compact, with a special focus on the impacts of Climate Change and how recent research may be incorporated into future activities.

Brent Nawrocki, Changhai Zhu and **Timothy B Johnson**, Ontario MNRF, Glenora Fisheries Station, Picton, ON, Canada. **Comparative trophic ecology of juvenile salmonids in nearshore Lake Ontario.**

Despite long-term broadscale fisheries monitoring programs, the trophic ecology of juvenile salmonids in nearshore Lake Ontario is not well understood. We used condition metrics as well as stomach content and stable isotope diet metrics to understand the trophic ecology of juvenile Atlantic salmon (*Salmo salar*), brown trout (*Salmo trutta*), Chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*Oncorhynchus kisutch*), rainbow trout (*Oncorhynchus mykiss*), and lake trout (*Salvelinus namaycush*). Salmonids had comparable stomach mass, and allometric patterns existed between fork-length and both relative stomach content mass and energy density for all species. Interspecific differences existed with respect to salmonid diet, and the magnitude of difference generally increased with increasing body size. Small sized salmonid (fork length < 100 mm) diets mainly consisted of Diptera (% volume = 66 – 100; prey isotope %: 11.7 –78.4), while large sized salmonids (fork length 200 – 300 mm) mainly consumed fish prey (% volume = 20–100; prey isotope % = 21.5 – 42.7). Salmonids exhibited interspecific niche overlap, with lake trout (SEAB = 22.9 ‰$^2$) and brown trout (18.6 ‰$^2$) having the largest isotopic niche size, and Atlantic salmon having the smallest (2.7 ‰$^2$). Our study addressed a knowledge gap in trophic ecology between mostly stream dwelling juvenile and open lake adult salmonid life stages, revealing differences in diet but comparable condition metrics which suggests different strategies to optimize performance in the nearshore environment.

Alison Palmer, Maria Ramirez, **Ashley Jones** and **Valerie Blakely**, University of Michigan, Ann Arbor, MI, USA. **Emphasizing natural infrastructure, equity, and justice in Great Lakes coastal resilience planning and management.**

The Great Lakes region is facing many intersecting coastal management challenges due to climate change. Conservation and restoration, especially through the use of novel infrastructure solutions, are some

of the avenues that will be explored as management options. With long-established industrialized shorelines dominating much of the region, finding and implementing such solutions that encourage and increase the benefits of more naturalized ecosystems pose logistical, cultural, and financial challenges. Subsequently, future conservation efforts must incorporate equity and justice to be effective collaborations with communities experiencing threats from continued climate change. Our research explores the role of conservation organizations in overcoming such challenges through exploring different community attitudes, perspectives and priorities related to community health and conservation, with a focus on equity and natural infrastructure. We conducted interviews & observations of 5 coastal communities with distinct demographic traits. We found a general lack of 'shovel ready' projects, and many situations lacking the labor capacity to effectively secure and utilize long-term funding. We found an awareness of natural infrastructure as a coastal management strategy, but many raised concerns with the feasibility of these types of solutions. These are some of the capacity voids through which these organizations can better help coastal communities implement natural solutions and address equity concerns.

**Catriona Lucy Clare Jones**, Paris D Collingsworth and Jacob Hosen, Purdue University, West Lafayette, IN, USA. **Drivers of Spatial and Temporal variability in Net Ecosystem Production within the Central Basin of Lake Erie.**

Lake ecosystem metabolism estimates gross primary production (carbon fixation) and ecosystem respiration (biological oxidation of carbon), which yields a metric (net ecosystem production, or NEP) through which to understand carbon cycling and energy transfer within a lake ecosystem. As such, it has become a powerful tool for understanding biogeochemical cycles and ecosystem-level effects of anthropogenic and natural stressors. Lake Erie has the most densely populated shoreline of any of the Laurentian Great Lakes and experiences high levels of agricultural and urban runoff, leading to frequent toxic algal blooms in the summer months. Efforts to reduce blooms have focused on reducing phosphorus loads from industrial and other sources within the catchment area. Although efforts were initially successful, there has since been a re-emergence of bloom events in the last 30 years. It is therefore clear that there are nuanced and complex dynamics controlling primary production and trophic state in the lake which need to be parsed before further mitigation plans can be successful. In this study, we obtained 5 years of high frequency water quality data (including dissolved oxygen, temperature, DOM fluorescence, chlorophyll- and phycocyanin fluorescence) collected between 2017 and 2021 from buoys moored in three offshore sites and five nearshore sites in the Central Basin of Lake Erie. We used these data to determine spatial and temporal trends in NEP before deploying deep machine learning to identify key environmental drivers of these trends.

**Luisa Jordao**[1], Ana Raposo[1], Catarina Mansilha[2,3], Alexander Veber[4,5], Armindo Melo[2,3], Joao Rodrigues[1], Rui Matias[1], Helena Rebelo[1], Jose Grossinho[1], Manuela Cano[1], Cristina Almeida[1], Isabel Nogueira[6], Ljiljana Puskar[5] and Ulrich Schade[5], [1]National Institute of Health Dr Ricardo Jorge, Lisboa, Portugal, [2]National Institute of Health Dr Ricardo Jorge, Porto, Portugal, [3]Associated Laboratory for Green Chemistry (LAQV) of the Network of Chemistry and Technology (REQUIMTE), University of Porto, Porto, Portugal, [4]Humboldt Universität zu Berlin, Institute of Chemistry, Berlin, Germany, [5]Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Infrared Beamline IRIS, Berlin, Germany, [6]Instituto Superior Técnico, MicroLab, Lisboa, Portugal. **Occurrence of persistent organic pollutants at Alqueva's surface water at touristic spots.**

Freshwater pollution is a huge concern. A study aiming to evaluate water quality and occurence of two groups of persistent environmental pollutants with similar chemical properties (polycyclic aromatic hydrocarbons-PAHs and microplastics -MPs) in Alqueva's surface water was performed during 2021. Samples were collected at three spots related to touristic activities (two beaches and one marina) once by season. In addition, we assessed and compared the presence of biofilms on plastic and natural materials. Water quality was acceptable with a low eutrophication level. PAHs concentration levels were lower than

the standard limits established for surface waters. PAHs profiles showed significant differences when comparing the dry and rainy seasons, with a higher number of different compounds detected in Spring. Low molecular weight compounds, usually associated with the atmospheric deposition and petroleum contamination, were more prevalent. MPs were detected in all samples except one during Winter. Eight polymers were detected being polyethylene the most frequent. Plastics were more prone to biofilm colonization than natural materials. In addition, biofilms detected on plastics were more complex with higher microbial diversity and richer in EPS. Among microbiota were identified microorganisms previously linked to plastic and PAHs detoxification suggesting the need for further studies to evaluate the viability of using biofilms as part of a green bioremediation strategy to mitigate water pollution.

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**Alexander Y. Karatayev** and Lyubov Burlakova, SUNY Buffalo State, Buffalo, NY, USA. ***Dreissena* in the Great Lakes: What have we learned in 35 years of invasion.**

We summarized over 35 years of research on zebra and quagga mussels in the Laurentian Great Lakes. Invasion dynamics, growth, and reproduction of dreissenids in the Great Lakes are governed by lake morphometry. In shallow polymictic lakes, lakes basins, and embayments quagga mussels became dominant 4 – 12 years after coexistence but did not fully replace zebra mussels even after 30 years of coexistence. In contrast, in deep Great Lakes quagga mussels became dominant faster at greater depths, form much higher density, and drive zebra mussels to virtual extirpation. At <30 m mussels overshot their carrying capacity and declined within 13 – 15 years after first detection. At 30 – 90 m their densities increased more slowly and declined to a lesser extent, while at >90 m populations continue to increase even after 35 years of invasion. After the proliferation of quagga mussels, benthic wet biomass increased about two orders of magnitude and currently exceeds zooplankton biomass >40-fold. Strong benthic/pelagic coupling redirects food and energy from the water column to the bottom causing an increase in Secchi depth, decline in phosphorus, chlorophyll, phytoplankton and zooplankton biomass. The abundance of commercially important fishes declined as a result of the dramatic decrease in their main food deep water amphipods *Diporeia*, which has been outcompeted by exotic mussels. However, the introduction of round goby provided an important link between dreissenids and commercially and recreationally valuable fish species, increasing their productivity.

**David Karpovich**[1], Sherry L Martin[2] and Douglas R Pearsall[3], [1]Saginaw Valley State Univ., University Center, MI, USA, [2]US Geological Survey, Lansing, MI, USA, [3]The Nature Conservancy, Lansing, MI, USA. **Status and Progress of monitoring activities by the Saginaw Bay Monitoring Consortium.**

The Saginaw Bay Monitoring Consortium (SBMC) began start-up activities in 2022 for tributary and Bay monitoring that is planned through at least 2026. Tributary sampling locations were carefully selected to capture coastal sub-watersheds of Saginaw Bay and major sub-watersheds of the Saginaw River. Site selection criteria included land use, proximity to the bay, and site flow characteristics. As a result, 18 tributary locations were established using 6 existing USGS gaging stations and 12 new gaging stations. Water sampling equipment will be installed in 2023 with sampling to commence late in the year. The result will be new, weekly data on nutrient and sediment transport at each of the 18 sites through 2026. Complementary data will also be collected at 10 open water sites on Saginaw Bay. This coordinated, comprehensive, multi-year monitoring effort is unprecedented in the Saginaw Bay Watershed, and it will build a significant data resource for use by resource managers, scientists, and decision-makers to assist in evaluating and restoring this very important ecosystem. This presentation will describe the decision-making and on-the-ground work leading to current progress as well as future plans of the SBMC.

**Naomie Kayitesi**[1], Alphonce C. Guzha[2], Marj Tonini[1] and Gregoire Mariethoz[1], [1]University of Lausanne, Institute of Earth Surface Dynamics, Lausanne, Switzerland, [2]Global Center on Adaptation, Rotterdam, Netherlands. **Quantifying Land Use Land Cover Changes and Impacts on Hydro-morphology in Sebeya catchment of the Lake Kivu Basin.**

Lake Kivu, bordering Rwanda and Democratic Republic of Congo (DRC) is one of the African Great Lakes (AGL), which are a series of Rift Valley lakes in and around the East African Rift. While the lakes are major economic drivers in the region, natural and anthropogenic activities are impacting the AGL. These lakes receive water from the surrounding catchments, that are undergoing severe Land Use Land Cover Changes (LULC). Furthermore, climate change is intensifying these changes due to global warming and increased frequency of extreme events (floods and droughts). These changes manifest in watershed and river hydro-morphological processes, alteration of rainfall- runoff patterns, and changes in the water balance. Lake Kivu is in a region with one of the highest population densities and growth rate (3.5%) in the AGL. Population increases are leading to changes in LULC and in turn to its hydro-morphology. The Sebeya river is one of the two primary inflows for Lake Kivu and any changes in its catchment attributes directly impacts the lake. This study aims at analyzing the LULC changes in Sebeya catchment in the last three decades and forecast future scenarios, using remote sensing data and a predictive LULC model. These LULC and climate changes are then related to associated changes in the catchment hydro-morphology. This study provides a foundation for prioritizing and implementing measures to restore and maintain the integrity of the Sebeya catchment and subsequently improve the health of Lake Kivu for sustained ecosystem service supply.

**Sarah Kaykhosravi**[1], Stephanie Slowinski[2], Yubraj Bhusal[2], Mahyar Shafii[2], Md Abdus Sabur[2], Krista M. Chomicki[3], Stephen Ruddy[4], Chris T Parsons[5], Fereidoun Rezanezhad[2] and Philippe Van Cappellen[2], [1]University of Waterloo, Waterloo, ON, Canada, [2]Ecohydrology Research Group, University of Waterloo, Waterloo, ON, Canada, [3]Toronto and Region Conservation Authority, Vaughan, ON, Canada, [4]Town of Ajax, Ajax, ON, Canada, [5]Environment and Climate Change Canada, Burlington, ON, Canada. **Urban phosphorus load estimation and speciation.**

We estimated the annual and seasonal loads of different phosphorus (P) chemical pools exported from two adjacent urban sewersheds (AJE and AJW) discharging in Lake Ontario. The two sewersheds differ in their land use: AJW is more residential and AJE more commercial/industrial. A load-flow regression model and a continuous P model PCSWMM were used and calibrated against measured data. The regression modeling yielded season-dependent export concentrations (ECs) for the two sewersheds. The annual total P (TP) loads from the sewersheds were significantly different (AJE: 0.61±0.05 kg/ha/year; AJW: 0.39±0.07 kg/ha/year). Compared to AJE, the TP loads from the more vegetated AJW were enriched in both total dissolved P (TDP) and dissolved reactive P (DRP). Overall, the TP loads were dominated by particulate P (83-91% of TP), with slightly higher values for AJE. Chemical extractions further suggested that close to half (38-47%) of the particulate P load consists of reactive P species. Thus, DRP alone may not provide a reliable measure of the potentially bioavailable P exported from urban areas.

**Elizabeth Kazmierczak**[1], Austin Happel[2], Fritz Petersen[1] and Timothy Hoellein[1], [1]Loyola University Chicago, Chicago, IL, USA, [2]Shedd Aquarium, Chicago, IL, USA. **Microplastics in fish relative to point source proximity and trophic level in an urban river.**

Microplastics (MP) (i.e., particles < 5 mm) are a global contaminant. Urban rivers are a critical source of plastics to oceans, and MP within rivers are retained in part though biological processes, including ingestion. MP ingestion by freshwater fish varies by proximity to point sources (e.g., wastewater treatment plants; WWTP) and trophic level, but few studies have examined both. We measured MP in 6 fish species of different functional roles at sites upstream, at the effluent release, and downstream a large WWTP outflow in Chicago, USA. We removed digestive tracts and measured MP via peroxide oxidation (i.e., abundance, shape, color, and polymer). We estimated trophic level via stable isotope analysis of $\delta^{15}N$ muscle tissues of

all individuals, and identified gut contents for two species (Bluegill, Round Goby). With all species combined, MP concentration were not significantly different across study sites, but stable isotopes increased downstream. Considered individually, MP abundance relative to WWTP proximity varied by species. Last gut contents were more strongly affected by site than species. This study reveals how stable isotopes, gut contents, and MP are highly variable among species in a large river with intensive human impacts, even across a relatively small geographic scale (10 km). Results will inform models of MP dynamics in freshwater ecosystems.

**Ebissa Gadissa Kedir**[1], CSP Ojha[2] and K S Hari Prasad[2], [1]Department of Civil Engineering, Roorkee, India, [2]IIT Roorkee, Roorkee, India. **Depth averaged velocity and Boundary Shear Stress distributions in Compound channels with Converging floodplains.**

In the present study, the depth-averaged velocity and boundary shear stress in non-prismatic compound channels with three different converging floodplain angles ranging from 1.43$^{e}$ to 7.59$^{e}$ have been studied. The analytical solutions were derived by considering acting forces on the channel beds and walls. In the present study, five key parameters, i. e non-dimensional coefficient, secondary flow term, secondary flow coefficient, friction factor, and dimensionless eddy viscosity, were considered and discussed. A new expression for non-dimensional coefficient and integration constants were derived based on the novel boundary conditions. The model was applied to different data sets of the present experiments and experiments from other sources, respectively, to examine and analyse the influence of floodplain converging angles on depth-averaged velocity and boundary shear stress distributions. The results show that the non-dimensional parameter plays an important in portraying the variation of depth-averaged velocity and boundary shear stress distributions with different floodplain converging angles. Thus, the variation of the non-dimensional coefficient needs attention since it affects the secondary flow term and secondary flow coefficient in both the main channel and floodplains. **Keywords:** Depth-average velocity, Converging floodplain angles, Non-dimensional coefficient, Non-prismatic compound Channels

**Steven Conor Keitzer**[1], Alexandra Fries[1], Heath Kelsey[2], Ann Foo[1], Annie Carew[1], William Dennison[2], Joseph Edgerton[1] and Lorena Villanueva-Almanza[3], [1]University of Maryland Center for Environmental Science, Annapolis, MD, USA, [2]University of Maryland Center for Environmental Science, Cambridge, MD, USA, [3]University of Maryland Center for Environmental Science, Toronto, ON, Canada. **Watershed-scale collaboration using socio-environmental report cards: An example from southeastern Michigan.**

Achieving social, economic, and environmental sustainability for watersheds requires collaboration among diverse stakeholders. However, collaboration is often stifled by differing priorities and an unclear understanding of current human and environmental conditions, and their linkages, among stakeholders. Here, we report on the development of socio-report cards for five watersheds in southeast Michigan to create a shared vision among local stakeholders for sustainability in their region. This project included over 30 indicators of social, cultural, economic, and environmental health chosen in collaboration with watershed groups and their stakeholders. Our results show important commonalities among these watersheds, but also highlight important unique challenges for different areas in the region. For example, while flooding is increasing across the region and an issue for all five watersheds, there are differing management tools needed to address floods in the rural and urban areas of southeast Michigan. The raised awareness of linkages between human well-being and environmental health and their current conditions that result from this project will help lead to collective action among diverse stakeholders in southeast Michigan.

**Martin Keller**, Barb Veale and Kim Barrett, Conservation Halton, Burlington, ON, Canada. **Making Nature Count – Findings of the Grindstone Creek Watershed Natural Assets Management Project.**

In 2019, Conservation Halton, the Cities of Hamilton and Burlington, and the Royal Botanical Gardens partnered with the Municipal Natural Assets Initiative and the Greenbelt Foundation to explore

the value of natural assets in Grindstone Creek in addressing natural resource issues, with a focus on stormwater management against increasing pressures from climate change. In the three years since, the project produced data, modelling, and strategies to ultimately integrate natural assets into long-term asset management. Specific outcomes included developing an interactive, web-based natural asset inventory, modelling to assess the role of natural assets in flood reduction, a valuation of how natural assets contribute to stormwater management and co-benefits, scenario development to consider future states of the watershed and analyses to inform continual improvement, and recommended next steps to advance comprehensive natural assets management efforts. The total value of stormwater management benefits of natural assets identified in the Grindstone Creek watershed is approximately $2 billion in terms of capital costs of equivalent engineered infrastructure assets to provide that same service. This project represents a new approach to assess potential for buffering climate change impacts and provides a case study and framework for watershed management. This presentation will provide an overview of the project, findings, and recommendations. The presentation will conclude with an outlook on next steps for implementing the recommendations.

**Wendy Kellogg**, School of Urban Affairs, Cleveland State University, Cleveland, OH, USA. **Knowledge mobilization for decision making in three Lake Erie watersheds.**

Knowledge mobilization through research, education and outreach is a critical component of watershed governance. Knowledge mobilization constitutes co-production and use of biophysical and social systems information to inform decision making and stakeholder engagement. Co-production of knowledge occurs when research information is applied to focal ecosystems, results are monitored, and stakeholders reflect on significance and outcomes. This presentation analyzes the co-production of knowledge in three different watersheds in northern Ohio : the Chagrin River, the Cuyahoga River and the Central Lake Erie basin. These three focal ecosystems exist at different geographic scales and organizational context. Knowledge mobilization is described in terms of mechanisms of transfer, purpose, and network learning that occurred. The cases describe knowledge frameworks (e.g., the ecosystem approach, resilience, etc.) and application of climate scenarios to inform local decision making and collaboration. Methods include document review and interviews of stakeholders and organization leaders.

**Heath Kelsey**[1], Alexandra Fries[2], Ann Foo[2], Annie Carew[2], Conor Keitzer[2], Joseph Edgerton[2], Lorena Villanueva-Almanza[3] and William Dennison[1], [1]University of Maryland Center for Environmental Science, Cambridge, MD, USA, [2]University of Maryland Center for Environmental Science, Annapolis, MD, USA, [3]University of Maryland Center for Environmental Science, Toronto, ON, Canada. **Socio-environmental report cards as tools for synthesis and collaboration at the watershed scale.**

Clear understanding of ecosystem health and societal linkages is difficult to obtain when information comes from multiple groups with different objectives. But this type of "high-level" information is what the public desire, and what elected officials need to make informed policy decisions. Socio-Environmental Report Cards have become recognized for their ability to distill clear and compelling messages from multiple sources of complex information. Moreover, the process for developing report cards strengthens collaborations and creates new partnerships, by engaging interested parties in a participatory process to create a consensus-based report card. The resulting report card can 1.) Provide clear and concise messages for policy makers based on complex, rigorous scientific data and information, 2.) Identify data and information gaps that were previously not recognized, and 3.) Create a framework for broad assessment of Socio-Environmental conditions. The University of Maryland Center for Environmental Science has been co-creating socio-environmental report cards globally since 2007. We will highlight our experiences in developing report cards at multiple scales over the past 15 years in Chesapeake Bay, Mississippi River, and Southeast Michigan watersheds. We suggest that this may also be a useful tool in Saginaw Bay.

**James Kessler**[1], Eric J Anderson[2] and Ayumi Fujisaki-Manome[3], [1]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, USA, [2]Colorado School of Mines, Golden, CO, USA, [3]Cooperative Institute for Great Lakes Research, University of Michigan, Ann Arbor, MI, USA. **Skill Assessment of Great Lakes Ice Models.**

Ice cover in the Laurentian Great Lakes is highly variable and highly influential to the region with wide-ranging impacts including those on meteorology, ecology, and economy. Due to the combination of variability and societal impacts, there is a long history of both observing the current state and predicting the future state of Great Lakes ice on various timescales. We evaluate the skill of NOAA's Great Lakes Coastal Forecast System (GLCFS) which is an application of the FVCOM-CICE that makes predictions on the order of several days. Previous ice model skill assessment has been primarily focussed on *lake-wide* average ice concentration (i.e. horizontal spatial extent) while little has been done to assess the spatial distribution of ice concentration or ice thickness performance. This falls short of user needs, because both ice thickness information and spatial distribution (i.e. not lake-wide) are critical for commercial shipping and navigation on the lakes during winter. Additionally model skill is compared to climatology and other Great Lakes models.

**Nusrat Nasrin Khan**[1], Rebecca Logsdon Muenich[1], Hans Paerl[2] and Silvia E Newell[3], [1]Arizona State University, Tempe, AZ, USA, [2]UNC-CH Institute of Marine Sciences, Morehead, NC, USA, [3]Wright State University, Dayton, OH, USA. **Assessment of Long-Term Variation of TKN concentrations in Maumee River.**

Harmful (toxic, hypoxia-generating, food web altering) algal blooms (HABs) deteriorate water quality and negatively impact ecosystem and human health in freshwater ecosystems. Nutrients from agricultural activities have been identified as a dominant source driving HABs globally. Lake Erie, too, suffers from accelerating eutrophication and resurgent HAB events due to excess nutrients derived from catchments in its Western Basin (WB). Phosphorus (P) has been identified as a key driver of these blooms and has therefore been the focus for researchers, managers and policymakers. The influence of nitrogen (N) on bloom dynamics including toxicity and recurrence has often been overlooked due to this exclusive focus on P. Total Kjeldahl nitrogen (TKN), the sum of organic N and ammonia-N, has not been the focus of eutrophication research in Lake Erie at the watershed scale, but has been linked to blooms in recent work. In this study, we replicate a seasonal decomposition of the TKN time series data by Loess (STL) to obtain a smooth long-term trend over the period of 1991 to 2021 and compared with similar work done on P. We then compare this trend to data on eutrophication and HAB development in the WB. From the STL trend analysis, we identified a high rate of increase in TKN from 1991 to 2010. From 2010 to 2021 a decreasing trend in TKN was observed. We compare this trend to available bloom indices for recent time periods. The results of this work provide further insight into additional non-P drivers of the blooms in Lake Erie which could help to advance nutrients mitigation strategies.

**Karen Kidd**[1], Ellie Weir[1], Bonnie Hamilton[2], Jiabao Wu[1], Mark Servos[3], Patricia Gillis[4], Adrienne Bartlett[4] and Gerald Tetreault[4], [1]McMaster University, Hamilton, ON, Canada, [2]University of Toronto, Toronto, ON, Canada, [3]University of Waterloo, Waterloo, ON, Canada, [4]Environment and Climate Change Canada, Burlington, ON, Canada. **Impacts of municipal wastewater treatment plant effluents on microplastics in riverine biota.**

Microplastics (MPs) are present in municipal wastewater treatment plant (WWTP) effluents, but it is unclear whether these contaminants are ingested by nearby biota. This study examined whether MPs in caged biota, resident fish, and environmental samples were elevated near two WWTP outfalls in the Grand River, southern ON. In fall 2019, amphipods, fluted-shell mussels, and rainbow trout were caged upstream and downstream of the Kitchener WWTP for 14-28 days. Wild rainbow darter were collected from up and downstream of the Kitchener and Waterloo WWTPs, along with surface water and sediments. Whole body amphipods, fish digestive tracts, and fluted-shell mussel tissues (hemolymph, digestive glands, and gills)

were digested in KOH; environmental samples were processed using filtration/density separation prior to visual identification. MP counts were elevated in trout caged at the outfall, compared to up- and downstream. Additionally, MP concentrations in sediment were significantly higher at the Waterloo outfall, compared to most other sites. Amphipods, mussel tissues, rainbow darter, and water did not show elevated counts downstream of discharges. Fibers were the most common morphology, and blue and clear particles were prevalent. These results indicate that WWTP effluents elevate MPs in some taxa and environmental samples, but MP presence was similar across most sites in both biotic and abiotic compartments and suggest widespread contamination of the river.

**Katarina Kieffer**, Samira Rifat Prova and Angelica Vazquez Ortega, Bowling Green State University, Bowling Green, OH, USA. **Characterizing the molecular composition of extractable humic material in a farm soil and lake dredged sediments.**

Eutrophication is an ongoing environmental problem for the Lake Erie watershed. Over the last 20 years, the region has seen an increase in harmful algal blooms (HABs) of toxic cyanobacteria. The Maumee watershed discharging at the Western Lake Erie Basin (WLEB) is contributing to the HABs in part due to nutrient pollution and sediment erosion from intensive agricultural land use. Additionally, sedimentation in the WLEB causes the need for frequent dredging of shipping channels in Toledo, with 800,000 cubic yards of dredged sediments (DS) removed annually to maintain the channels. Previous research has indicated that DS are beneficial as a farm soil amendment, as they are enriched in phosphate ($PO_4^{-3}$), nitrate ($NO_3^-$), and soil organic matter (SOM). The largest component of SOM is humic substances, which play a role in nutrient sorption and release and contribute to soil and plant health. The research objective of this study is to characterize the humic substances in DS and farm soil to gain insights on the relationship between $PO_4^{-3}$ and $NO_3^-$ sorption and the molecular composition of different humic fractions. SOM from DS and farm soil will be extracted using Humeomics, a sequential chemical extraction process. The extracted fractions will be characterized using mass spectrometry, including GC-MS, LC-MS, FTIR, and fluorescence spectroscopy. Preliminary results from DS characterized with fluorescence spectroscopy showed the presence of several components including terrestrial humic-like and fulvic-like, and protein and tryptophan-like microbial.

**Lucyphine Julius Kilanga**, AWIS Cohort 2023, Mwanza, Tanzania, United Republic of. **Future climates impacts and adaptation for women in small scale fisheries along Lake Victoria.**

Climate change disproportionately affects marginalized groups, especially women in small scale fisheries along the Lake Victoria, the effects has already exemplified itself in different ways including periods of prolonged drought and unpredictable seasonal weather patterns which has triggered some ecological changes. The changes include declining fish stock directly affecting the fishing operations and fishing communities.as these changes take place majority of women processors and traders have become destitute with no reliable economic and an assured food providing activity. The results shows that climate change has and will impact on the links in the supply chain for women in small scale fisheries (e.g., producers, processors, those transporting and selling fish) affecting their livelihood in terms of incomes, value added, employment and food security due to the declined fish caught (that has led to decreased processed products), uncertain fish harvest season, and further fishing area. However, women processors and traders are aware of the climate change and how it affects food security, but have low adaptive capacity and resilience due to lacking resources and interventions to fight against climate change risks and crisis. Therefore, collective policies should address development strategies to be performed such as diversification of processed products, improvement of processed product quality to prolong the product shelf life, supportive financial schemes and marketing network, to enhance women resilience on impacts of climate change.

**Loren King**, Wilfrid Laurier University, Hamilton, ON, Canada. **Community Finance Strategies for Citizen Science: an ongoing experiment with the Great Lakes Trust.**

Reflections on an ongoing effort to think about citizen science and water advocacy in broad terms ... and then to finance those efforts by finding a space between public purposes, private-sector innovation, and charitable giving. Both academic and corporate research have familiar (if often frustrating) funding models ... what about citizen science? For the better part of a decade, the Great Lakes Trust has been thinking about how to provide micro-grants and social venture capital to support a range of projects relating to Great Lakes watershed integrity, pollution management, and fair and sustainable access to recreational shores and waters. This presentation reports on some of what we've found, and how we plan to keep building funding models to support and foster both community-based and private sector creativity harnessed for the public good.

**Trina King**[1], Christopher Lemieux[1], Scott Parker[2] and Dan Kraus[3], [1]Wilfrid Laurier University, Waterloo, ON, Canada, [2]Parks Canada, Tobermory, ON, Canada, [3]Wildlife Conservation Society Canada, Toronto, ON, Canada. **Canada's Great Lakes Coastal Protected Areas.**

In December 2022, the *Kunming-Montreal Global Biodiversity Framework* was agreed to by the member nations to the UN *Convention on Biological Diversity*, including Canada. Target 3 of the GBF calls for the conservation of at least 30% of terrestrial and marine areas by 2030 through protected areas and other effective area-based conservation measures. A key aspect of this target includes consideration for the effective conservation and management of coastal areas, which have received limited attention globally and within Canada. While coastal areas are valued for their social, cultural, and ecological importance, the planning and establishment of coastal protected or conserved areas is often incidental to efforts to conserve solely terrestrial or, increasingly, marine ecosystems. Furthermore, coastal areas are particularly vulnerable to the impacts of climate change, and continue to experience high rates of ecosystem and species loss. Considering these challenges, we detail the current protection status of coastal areas along Canada's Great Lakes coast and discuss their contribution as natural solutions to the biodiversity and climate crises.

**Greg Kleinheinz**, Carmen Ebert, Rebecca Klemme and Hannah Seefeldt, University of Wisconsin Oshkosh, Oshkosh, WI, USA. **Regional Approach to Marine Debris Removal in Northern Lake Michigan.**

Marine debris has been a significant issue in select marine environments for some time. However, the problem has grown in the breadth of area impacted over the years and now is impacting locations like the Great Lakes. While macro debris is a major issue for aesthetics, it also contributes to the overall loading of microplastics in water and beach sand throughout the Great Lakes. This presentation will explore a regional approach to removal of marine debris via boat collection using an Elastec Omni Cat marine debris boat, a Pixiedrone autonomous trash collection drone, SeaBins installed at marinas, as well as the BeBot remote controlled beach cleaning system. These technologies were deployed on a rotating schedule in northern Lake Michigan in communities such as Green Bay, Sturgeon Bay, and Manitowoc. The technologies used will be evaluated for their usefulness in single locations versus a rotating regional approach. A characterization of the marine debris recovered will be presented as well as microplastic data from both water and beach locations in Door County, WI. Understanding the marine debris present will help inform educational programming moving forward. Further, understanding how marine debris contributes to microplastic debris in the water and beaches will be critical in developing education and mitigation strategies.

Michael Zorn[1], Jessica Grow[2] and **J. Val Klump**[2], [1]University of Wisconsin-Green Bay, Green Bay, WI, USA, [2]University of Wisconsin-Milwaukee, Milwaukee, WI, USA. **IOT networking & remote environmental monitoring in Green Bay's hypoxic-prone waters.**

In partnership with a local cellular and communications services provider, Cellcom, low cost, real-time sensor arrays were developed using long range, low power, wide area networking (LoRaWAN) protocol to wirelessly connect battery operated "things" to the internet as part of a regional environmental sensing network in Green Bay's hypoxic-prone waters. Two sensor packages were evaluated: 1) a Nexsens temperature string (4 nodes) and a bottom In-Situ dissolved oxygen/temperature sensor combination, and 2) two optical Yosemitech sensors, a chlorophyll-a fluorescence/temperature sensor and a phycocyanin fluorescence/temperature sensor. These combined devices sent LoRaWAN data packets out at programed intervals to Cellcom's mega/field gateways and then to Aexonis' Cemtore IOT mediation and management software platform. The data were subsequently integrated with GLOS's Seagull platform. Multiple electrical component configurations were evaluated to make both systems as robust and operator friendly as possible, including various solar controllers, battery packs, and microcontrollers. A Dragino RS485-LN LoRaWAN Converter was relatively simple to configure and proved to be a reliable means for data conversion and transmission over LoRaWAN, despite its lack of data-logging capabilities.

**Savannah Knorr**[1], Chris Grant Weisener[1] and Lori Phillips[2], [1]Great Lakes Institute for Environmental Research, University of Windsor, Windsor, ON, Canada, [2]Agriculture and Agri-Food Canada, Harrow, ON, Canada. **Agricultural land and storm events alters the biogeochemical cycling capacity of aquatic and sediment environments.**

Lake Erie is the most at risk of the Great Lakes for degraded water quality due to non-point source pollution caused by agricultural activities in the lake's watershed. This research investigates how agricultural sources alter the nutrient cycling microbial communities in receiving aquatic and sediment environments, whether functional communities in agricultural sources are linked to downstream aquatic and sediment environments, and how distance from an agricultural source, precipitation, and areas of natural filtration alter nutrient concentrations and nutrient cycling in aquatic and sediment environments. Water and sediment samples were collected during the May-November 2021 period along an environmental transect of Wigle Creek, which drains to Lake Erie. Nutrient concentrations were measured and N – and P – cycling functional potentials were assessed through quantitative PCR. Our findings for the aquatic environment indicate that nutrient concentrations and microbial nutrient cycling potentials increase during storm events, but are curtailed through natural filtration areas, and show significant declines with distance from the agricultural sources. In contrast the sediment environment was more resilient to agricultural disturbances and abiotic factors.

**Carolina Koebel**, Claire M Stevens, Paul C Frost, Nolan J. T. Pearce and Marguerite A Xenopoulos, Trent University, Peterborough, ON, Canada. **The effect of N:P ratio on growth rates of Lake Erie phytoplankton.**

Cyanobacteria *Microcystis sp.* and *Dolichospermum sp.* are known to form harmful algal blooms (HABs) in Lake Erie. Toxic microcystins produced during bloom formations represent a considerable risk to both municipal drinking water and to those that use the lake for recreation. The mechanisms for microcystin production are not completely understood, but research suggests that toxin production is more likely at high dissolved nitrogen (N) to phosphorus (P) ratios because of the high nitrogen content of the microcystin molecule. To contribute to the understanding of HAB formation and toxicity, we conducted a 72-hour in-situ bioassay experiment in the western basin of Lake Erie. Bioassay bottles were filled with ambient lake water and supplemented with nitrate to achieve a range of N:P ratios; no phosphorus was added. Selected ratios ranged from 4:1 to 124:1 N:P and were reflective of common N:P ratios observed in Lake Erie. Preliminary results show increased carbon specific nitrate uptake rates in bioassays with higher N:P ratios, but carbon specific growth rates and particulate C:N ratios varied insignificantly. In the short-term, it appears that Lake Erie phytoplankton respond to changing N:P ratios. To further investigate the role of N:P ratios, we will examine changes in phytoplankton community composition through pigment and microscopic analyses.

**Scott T Koenigbauer**[1], David G Fielder[2], Paris D Collingsworth[3] and Tomas O Hook[3], [1]Purdue University, West Lafayette, IN, USA, [2]Michigan DNR, Alpena Fisheries Research Station, Alpena, MI, USA, [3]Illinois-Indiana Sea Grant, West Lafayette, IN, USA. **Surveying spawning utilization of a restored reef in Saginaw Bay, Lake Huron.**

In Saginaw Bay, an Area of Concern in Lake Huron, native species spawn in multiple locations, including tributaries, nearshore and offshore reef habitats. However, broad-scale sedimentation has degraded the quality of historical reef habitat. Therefore, reef restoration throughout Saginaw Bay has the potential to benefit population recruitment of many lithophilic spawning species. In 2019, a 0.8 ha portion of historical Coreyon Reef was restored by supplementing new rock material. Post-restoration (2020-2022), we assessed spawning utilization of the reef by walleye (*Sander vitreus*) and lake whitefish (*Coregonus clupeaformis*), using sampling techniques standardized to pre-restoration surveys. To capture potential spawners and egg predators, we deployed large- and micro-mesh gillnets over the reef. To determine egg deposition rates, we set benthic egg mats. To assess water quality, we deployed dissolved oxygen loggers at Coreyon Reef overwinter. Through our surveys, we found that moderate numbers of individuals of both species were utilizing the restored site for spawning less than three years post-construction. Specifically, we collected spawning adult fish and collected eggs deposited onto the reef. Moreover, we did not find evidence of hypoxic conditions over winter. While initial utilization of the reef by spawning fish was fairly low, this may increase as subsequent generations return to the reef to spawn.

**Nigarsan Kokilathasan**, Basirath Raoof and Maria B. Dittrich, University of Toronto Scarborough, Toronto, ON, Canada. **Impacts of Polystyrene Nanoplastics on the Cell Surface Properties of *Synechococcus* and *Spirulina* .**

When plastic debris end up in aquatic environments, they can undergo degradation processes to form nano-sized plastic particles, or "nanoplastics" (NPs), defined as plastic particles less than 1 μm in size. Based on the chemical composition of the plastic particles and surrounding environment, NPs will elicit a charge. As the outer cell surface of most freshwater and marine bacteria are negatively charged, there is the potential for electrostatic interactions between NPs and the cell surface to occur. Picocyanobacteria *Synechococcus* has been shown to influence the cycling of phosphorus (P) and formation of calcium carbonate ($CaCO_3$) on their cell surface. Microalgae *Spirulina* is commonly used as a nutrient supplement and has been shown to biosynthesize metal nanoparticles. Little is known on the impacts of NPs on these microorganisms, particularly on their cell surface properties. The goal of this study is to examine the interactions between NPs and the cell surfaces of picocyanobacteria *Synechococcus* and microalgae *Spirulina*. We investigated the potential impacts of synthetic NPs to cell growth, morphology, and cell surface properties. Studying the impacts of NPs on cell surface properties can provide insights on the ecological interactions and biogeochemical functions that are dependent on the cell surface.

**Christopher Kotalik**[1], Sarah Janssen[2], Collin Eagles-Smith[3], Gale Beaubien[4], Joel C Hoffman[5], Marc Mills[4] and David Walters[1], [1]USGS, Columbia Environmental Research Center, Columbia, MO, USA, [2]USGS Mercury Research Lab, Madison, WI, USA, [3]USGS, Forest and Rangeland Ecosystem Science Center, Corvallis, OR, USA, [4]USEPA, Office of Research and Development, National Risk Management Research Laboratory, Cincinnati, OH, USA, [5]USEPA ORD Great Lakes Ecology and Toxicology Division, Duluth, MN, USA. **Mercury stable isotopes track aquatic to terrestrial subsidies.**

The transfer of aquatic contaminants, including mercury (Hg), to terrestrial food webs can often result in deleterious effects to wildlife health. While research has implemented the use of shoreline spiders to assess aquatic to terrestrial transfers of Hg, it is unclear if Hg sources, estimated from isotope ratios, can be successfully resolved to inform site assessments and remedy effectiveness. In this study, we apply Hg stable isotopes to assess if spider tissues can preserve aquatic Hg source signatures across a range of habitats within two Great Lakes tributaries. Results showed a strong 1:1 relationship for $\delta^{202}$Hg between shoreline spiders (*Tetragnatha* spp.) and aquatic insect larvae, confirming a direct link between aquatic and terrestrial

food webs with no evidence of internal fractionation due to insect metamorphosis or trophic fractionation associated with insect consumption. Assessment of different spider taxa within the same site revealed that Hg stable isotopes varied on the family level, likely because of differences in prey and habitat usage, which highlights the importance of spider taxa selection for Hg monitoring efforts. These results demonstrate the value of using shoreline spiders for Hg source attribution as well as the potential benefit of these tracers for examining trophic connections in complex food webs.

**Corey A Krabbenhoft**[1], Stuart A. Ludsin[2], Elizabeth Marschall[3], L. Zoe Almeida[4], Zachary Feiner[5], Andrew E. Honsey[6] and Gretchen JA Hansen[7], [1]University at Buffalo, Buffalo, NY, USA, [2]Aquatic Ecology Laboratory, The Ohio State University, Worthington, OH, USA, [3]The Ohio State University, Columbus, OH, USA, [4]Oregon State University, Corvallis, OR, USA, [5]Wisconsin Department of Natural Resources, Office of Applied Science, Science Operations Center, Madison, WI, USA, [6]USGS Great Lakes Science Center, Millersburg, MI, USA, [7]University of Minnesota, St. Paul, MN, USA. **A quarter-century decline in walleye recruitment.**

Climate change and other anthropogenic stressors have been linked to walleye (*Sander vitreus*) recruitment declines. However, individual walleye populations can be expected to differentially respond to such stressors because their effects are mediated by local environmental context (e.g., lake size). To test the hypothesis that the relationship between walleye recruitment and climate varies with environmental context, we analyzed recruitment synchrony in long-term walleye datasets collected across this species' North American range. Walleye recruitment was highly variable during the 1980s through the early 1990s and has declined on average throughout its range since the late 1990s. Although recruitment variation was highest in the largest lakes, patterns of decline have largely been driven by populations in relatively small inland lakes. Lake surface area and geographic location explained the most variation in recruitment, but climate conditions were also important, with moderate growing degree days, moderate winter severity, and high spring warming rates being associated with high recruitment. Our work illustrates potential shifts in walleye population sustainability as environments continue to change, and highlights the utility of long-term datasets in guiding future management and conservation strategies.

**Alicia Krause**[1], Jared Homola[2], Wesley Larson[3] and Yue Shi[4], [1]Wisconsin Cooperative Fishery Research Unit, Molecular Conservation Genetics Lab, University of Wisconsin-Stevens Point, Stevens Point, WI, USA, [2]U.S. Geological Survey, Wisconsin Cooperative Fishery Research Unit, Molecular Conservation Genetics Lab, University of Wisconsin-Stevens Point, Stevens Point, WI, USA, [3]National Oceanographic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, Auke Bay Laboratories, Juneau, AK, USA, [4]College of Fisheries and Ocean Sciences, University of Alaska Fairbanks, Juneau, AK, USA. **Assessing spatial and temporal variation in lake whitefish stock mixing rates throughout Lake Michigan.**

Fish stocks are biologically distinct intraspecies groupings that often arise from isolated spawning, leading to subsequent genetic differentiation. Tagging and genetic studies suggest Lake Michigan lake whitefish stocks mix during non-spawning periods when commercial harvest occurs, leading to concerns that more vulnerable stocks could experience over-harvesting. Our objective is to determine spatial and temporal variation of lake whitefish stock mixing throughout Lake Michigan. We are using genotyping-in-thousands to genotype 476 single nucleotide polymorphisms to inform mixed-stock analyses (MSA) that will quantify contributions from each of seven genetically delineated stocks to 32 mixed stock sample sets collected throughout Lake Michigan from 1977-2022. MSA results indicate variable mixing between archived and modern samples in some locations, such as northern Lake Michigan, where local stocks shifted from minority contributors in 1977 to a majority in 2019. Stocks originating from outside the management zone of harvest regularly make up 10-30% of harvest, indicating a violation of the stock assessment assumption of local origins for harvested individuals. This project is advancing the understanding of lake whitefish stock mixing and highlighting the relevance of genetic tools for monitoring managed species.

**Dan Kraus**, Robyn Rumney and Ciara Raudsepp-Hearne, Wildlife Conservation Society Canada, Toronto, ON, Canada. **Identifying Key Biodiversity Areas in the Great Lakes.**

Key Biodiversity Area (KBA) are being identified around the world to highlight the most important places for the persistence of biodiversity. Standard criteria to identify KBAs have been developed globally by the International Union for Conservation of Nature, with additional national criteria developed in Canada by the KBA Canada Coalition. Sites can be identified for species and ecosystems under any of five criteria: threatened biodiversity, geographically restricted biodiversity, ecological integrity, biological processes, and irreplaceability. KBAs are not prescriptive and are intended to help guide land use planning and sustainable development, the establishment of protected and conserved areas, and to inspire local efforts to protect nature. Many KBAs of global and national significance have been identified in the Great Lakes with addition sites currently under review. KBAs highlight Great Lakes waters, islands, and coasts that contribute to global and national targets to conserve biodiversity and provide important ecosystem services to local communities. We will provide context on KBAs and the KBA criteria and showcase some of the Great Lakes KBAs that have been identified to date. Opportunities to leverage KBAs in the Great Lakes to direct conservation efforts and to enhance monitoring of habitat and species will be explored.

**Joseph R Krieger**[1], Deborah H. Lee[1], Ashley K Elgin[2], Rochelle Sturtevant[3], Edward Rutherford[1], Doran M Mason[1] and Hongyan Zhang[4], [1]NOAA GLERL, Ann Arbor, MI, USA, [2]NOAA GLERL, Muskegon, MI, USA, [3]NOAA/GLERL - GLANSIS, Michigan Sea Grant, Ann Arbor, MI, USA, [4]Eureka Aquatic Research, LLC, ANN ARBOR, MI, USA. **NOAA Initiatives to Study and Manage Invasive Species in the Great Lakes and Beyond.**

Aquatic invasive species have been identified as one of the most pervasive and prevalent threats to the ecological and economic health of the Great Lakes region. At present, more than 180 non-native species are established throughout the region, many of which are considered invasive and cause harm. As a resource management agency, the National Oceanic and Atmospheric Administration (NOAA) has specific congressional and executive direction to manage invasive species both at the national-level and within the Great Lakes region specifically. This presentation will start with an overview of NOAA's legislative authorities related to invasive species, specifically focusing on its' participation on and leadership roles with two national-level interagency task teams, the Aquatic Nuisance Species Task Force and the National Invasive Species Council. We will then focus our presentation on the Great Lakes region and highlight NOAA's invasive species work which supports priorities highlighted under each of the five Great Lakes Lakewide Action Management Plans and aids in the monitoring and reporting of new and existing invasive species within the region.

**Yulong Kuai**[1] and Mathew Wells[2], [1]University of Toronto Scarborough, Toronto, ON, Canada, [2]University of Toronto, Toronto, ON, Canada. **Physical drivers of hypoxia in a large polymictic lake: examples from western basin of Lake Erie.**

Polymictic lakes experience alternate periods of mixing and stratification that is commonly driven by meteorological conditions. With the presence of seasonal thermal stratification, hypoxia can be developed in the bottom layer of the lake (hypolimnion); however, episodes of weak stratification in shallow polymictic lakes can potentially trigger hypoxia as well. In this study, we used temperature, dissolved oxygen (DO) and current velocity data during summer from Pigeon Bay in western Lake Erie in 2021 to analyze the correlation among these parameters. During the study period in 2021, there were variations regarding these parameters at two stations that were located at a near-shore municipal water intake on north side of the bay and the exchanging boundary between western basin and main basin of Lake Erie, respectively. Both sites shown the pattern of a 2 °C vertical temperature difference would trigger great drop of benthic DO saturation to less than 50 %. However, water was experiencing more frequent overturns near the water exchanging boundary due to upwellings from the central basin to the western basin. Thus, great variations in temperature and DO were expected as well as the higher east-west current velocity at this site. Site near the

water intake experienced stratification and hypoxia lasted for 5-6 days during the summer as the near-shore area was less dynamic. By using bulk Richardson Number, the status of the water column could be predicted, and hence the correlation among temperature, DO, and current velocity that trigger hypoxia

**Tyler Alexander Kunze**[1], Harvey A. Bootsma[1] and Brenda Lafrancois[2], [1]University of Wisconsin-Milwaukee, Milwaukee, WI, USA, [2]National Park Service, Ashland, WI, USA. **Benthic algal and macroinvertebrate response to the removal of dreissenid mussels in Lake Michigan.**

Dreissenid mussels have changed the fundamental community structure and biogeochemical processes of the Lake Michigan nearshore zone. There is evidence that dreissenids promote the growth of benthic algae and provide habitat and food for other benthic macroinvertebrates. The goal of this project was to further our understanding of the relationship between dreissenids, benthic algae, and benthic macroinvertebrates in the Lake Michigan nearshore zone. This was done by removing the mussels from a 140 $m^2$ area of rocky substrate and subsequently monitoring the response of the benthic community over a one-year period. Measurements included benthic algal biomass, productivity, taxonomic composition, phosphorus content, and stable isotope composition, as well as benthic invertebrate abundance and taxonomic composition. While algal biomass on the mussel-free site remained comparable to that on a control site, algal P content and productivity were significantly lower on the mussel-free site, and there were major differences in algal taxonomic composition between the two sites. Invertebrate abundance was also much lower on the mussel-free site. These findings can be used to explore the effects of any future large scale dreissenid removal efforts on nuisance benthic algae and nearshore food web structure.

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**Mark Labib**[1] and Radu Guiasu[2], [1]University of Ottawa, Ottawa, ON, Canada, [2]Biology Program, Glendon College, York University, Toronto, ON, Canada. **The origins of the negative attitudes towards the rusty crayfish (*Faxonius rusticus*) in North America.**

The rusty crayfish (*Faxonius rusticus*) is native to North America. The extent of this native range is controversial. There is evidence that the rusty crayfish may actually be native to parts of the Great Lakes region. Despite this, the rusty crayfish is widely considered as an invasive species on its home continent, and most of the articles published about this species in the last three decades focused on the negative impact of this crayfish in North America. We have conducted a thorough literature review, by analyzing 575 scientific publications, published between 1852 and 2020, which mention the rusty crayfish, and we have analyzed the evolution of attitudes towards the rusty crayfish. Publications which referred to this crayfish as "invasive", and/or focused on negative aspects related to *F. rusticus*, and called for the eradication of this species from various jurisdictions were classified as indicative of a negative approach towards this crayfish. We counted all articles, negative or neutral, and grouped them by decade, for the entire period examined for this study. The negative attitudes towards the rusty crayfish have intensified in the last three decades, and the expansion of the negative approach to this species coincided with the growth of the young field of invasion biology. We argue that the negative approach towards the rusty crayfish is subjective, and influenced more by the perception of this crayfish as "invasive", rather than by an objective examination of the actual ecological roles this species plays in various local ecosystems in the Great Lakes region.

**Rachel Lackey**[1], Ceilidh Mackie[1], James W. Roy[2] and Jana Levison[1], [1]University of Guelph, Guelph, ON, Canada, [2]Water Science and Technology Directorate, Environment and Climate Change Canada, Burlington, ON, Canada. **Geochemical determination of chloride sources in waters across various land uses of an Ontario watershed.**

The western portion of the Lake Ontario Basin has experienced increasing chloride concentrations over the last century, corresponding with urbanization in southern Ontario. The rise in chloride has been attributed to an increase in anthropogenic inputs, specifically road salt, landfill leachate, wastewater, agricultural products, and water softeners. To better understand the main sources of anthropogenic chloride in the Basin, groundwater and surface water samples were collected at sites of varying land uses across the Credit River watershed for one year. Samples were analyzed for major ions ($F^-$, $Cl^-$, $Br^-$, $PO_4^{3-}$, $SO_4^{2-}$, $Na^+$, $K^+$, $Mn^{2+}$, $Ca^{2+}$, $Mg^{2+}$) and isotopic tracers ($\delta^3H$, $\delta^2H$, $\delta^{18}O$, $\delta^{37}Cl$). Contaminant end members were determined by analysis of $Cl^-/Br^-$ ratio plots. Further examination of the ion suite, artificial sweeteners as wastewater and runoff tracers, and analysis of isotopic tracers guided the placement of each sample on binary mixing curves. Geospatial evaluation of past and present land uses for potential chloride sources helped further results from the geochemical analysis. Results from $Cl^-/Br^-$ ratio plots suggest a mix of road salt, landfill, and wastewater, especially at the most urban site. To further distinguish sources of anthropogenic chloride at each site geochemical parameters were examined on a seasonal basis. The results of this research aim to inform land use specific policies and guide recommendations for better management of anthropogenic chloride inputs across the Great Lakes Basin and beyond.

**Robert Ladwig**[1], Arka Daw[2], Cal Buelo[1], Anuj Karpatne[2], Hilary Dugan[1] and Paul Hanson[1], [1]Center for Limnology, University of Wisconsin-Madison, Madison, WI, USA, [2]Virginia Tech, Blacksburg, VA, USA.
**Combining 1D process-based modeling with deep learning in a modular compositional learning framework.**

Sound predictions by aquatic ecosystem models are needed to project how global change will affect lake ecosystem dynamics, phenology and services, globally. One-dimensional lake models are considered state-of-the-art tools for simulating heat fluxes, the vertical abundance of nutrients, etc., especially when computational feasibility precludes use of higher dimensional models. Recently, knowledge-guided machine learning models, which pretrain deep learning models with numerical model output, have shown improved performance over their process-based counterparts for the simulation of water temperature, phosphorus and cyanobacteria. Here, we develop a modular compositional learning framework that consists of a modularized integral energy model, in which individual modules are replaced by multi-layer perceptrons. By training the deep learning models with the output of the process-based modules, and subsequently finetuning them on observed high-frequency temperature data, we can increase the overall model performance drastically. The finetuned modular compositional learning framework improved the overall model's projections of oscillations at the thermocline depth and deep water heat transport. The methodology could be applied to existing process-based model structures to make the projections more robust and improve model performance. Conceptually, this methodology developed for one-dimensional models could eventually be up-scaled to 3-D models necessary to replicate physical dynamics in the Great Lakes.

**Celine Lajoie**[1], Colleen Dawson[2], Karen Kidd[1], Scott Capell[3], Erik JS Emilson[3] and Robert Mackereth[4], [1]McMaster University, Hamilton, ON, Canada, [2]University of Alberta, Edmonton, AB, Canada, [3]Great Lakes Forestry Centre, Natural Resources Canada, Sault Ste. Marie, ON, Canada, [4]Centre For Northern Forest Ecosystem Research, Ontario MNRF, Thunder Bay, ON, Canada. **The effects of forestry and beaver dams on mercury dynamics in Ontario's Boreal stream food webs.**

Beaver dams and forest harvesting co-occur across Ontario and potentially have cumulative impacts on streams altering food web structure and increasing the transfer of contaminants (e.g. mercury (Hg)) stored in forest soils to surface waters. To evaluate the influence of forest harvesting on Hg bioaccumulation in dammed stream food webs, harvested and non-harvested watersheds near Thunder Bay were sampled for terrestrial (leaves and detritus) and aquatic (biofilm) food sources, primary consumers (invertebrates) and predators (Blacknose Dace and Lake Chub) upstream and downstream of the beaver dams. Stable isotopes (C and N) and Hg concentrations were measured in samples to determine stream food

web structure and trophic transfer of Hg. In harvested reaches downstream of dams, both invertebrates and fish had a higher reliance on biofilm carbon. Higher Hg concentrations were observed in Blacknose Dace from harvested streams, but not in Lake Chub, and concentrations did not differ upstream or downstream of dams. Analyses of Hg concentrations of invertebrates and basal resources are ongoing to quantify mercury biomagnification. This research can help guide Boreal forest management practices around dammed lotic systems and support the goal of emulating, and not exceeding, the effects of natural disturbances.

**Nicole Latulippe**, University of Toronto Scarborough, Scarborough, ON, Canada. **Connecting Indigenous Placemakers and Caring for Place in Toronto.**

*Connecting Indigenous Placemakers* was a week-long practitioners' retreat and public symposium held on Menecing, the Toronto Island (Treaty 13a). It came together through a Mississaugas of the Credit First Nation (MCFN) and Ngā Aho Māori Designers' Network partnership. Based on the success in Aotearoa New Zealand of supporting Indigenous placemaking practitioners and shaping opportunities through a network, the gathering created a supportive space for Indigenous creatives to be on the land, work on collective and individual projects, build relationship with one another, share knowledge, and shape broader discourse on Indigenous placemaking in Toronto. As retreat participants integrated the teachings of Menecing, the Treaty Lands and Territory of the MCFN and a gathering place of many nations, the group began referring to the project as Maanjiwe Nendamowinan, the Gathering of Minds. This co-creative experience made clear the primacy of Place. That is, "we don't make place – Place makes us". Grounded in Menecing, and in dialogue with many voices, we demonstrate the more-than-ontological significance of Indigenous conceptualizations of and relational practices in uppercase-*P* 'Place' (an entity with a specific identity). We conclude with key considerations that keep Place and Place-keeping at the heart of research: Respect for the sacred, living well with all our relations, working with the peoples of Place, and rethinking 'research'.

Vincent Fortin, Nicolas Gasset, Milena Dimitrijevic, Dikra Khedhaouiria, Ryan Muncaster and **Audrey Lauer**, Environment and Climate Change Canada, Dorval, QC, Canada. **Back extension of the ECCC's Regional Surface and Precipitation Reanalysis.**

ECCC is producing the North American Surface and Precipitation Reanalysis at 10 km resolution covering the period of 1980 to present. The ongoing interest to improve the representation of the past weather in order to better characterize and ultimately adapt to climate change, led us to explore the possibility of extending the reanalysis into the past and going back to 1950. The preliminary simulation will be conducted for the water year of 1973; starting in October 1972 and extending to the end of 1973. This year is chosen because it is a part of the International Field Year for the Great Lakes and large amount of meteorological and limnological data for Lake Ontario are available that could be used in the initialisation and/or verification of the simulations. As for the standard reanalysis data, the comparison with observations and ERA5 for the 2m temperature, 2m dew point temperature and 10m wind speed will be presented. An off-line precipitation analysis will also be produced and evaluated in terms of probability of detection, equitable treat score and alarm ratio.

Lydia Smith[1], **Bernard Laval**[1], Svein Vagle[2] and Eddy Carmack[2], [1]University of British Columbia, Vancouver, BC, Canada, [2]Fisheries and Oceans Canada, Sidney, BC, Canada. **Deep Water Renewal in a thermobarically stratified fiord-type lake.**

Thermobarically stratified Quesnel Lake is a fjord-type freshwater lake that shows relatively high rates of bottom water ventilation over winter. A decade-long data set reveals annual winter trends of net cooling at 500 m depth. As well, field measurements recorded increasing hypolimnetic oxygen levels over winter, further demonstrating seasonal ventilation. This research describes field observations from winter

2006-2007, a winter with substantial spatial coverage of moored instruments in this topographically complex lake. Results suggest deep water is first ventilated by thermobaric instability induced by baroclinic seiche, and later in the season by a prolonged vernal turnover, during which seiche-induced benthic mixing homogenizes bottom water (within 0.02ºC) to a maximum height of ~400 m above the lake bottom. This thick benthic layer overlaps a surface mixed layer to allow a full-depth spring turnover. Our observations support previous studies of Quesnel Lake, demonstrating that wind forcing is an important driver of mixing and transport even to 500 m depth in a thermobarically stratified fjord-type lake.

**Sarah Lavoie-Bernstein**[1,2], Razegheh (Raz) Akhbarizadeh[3], Jasmine Yu[1], Julian Aherne[4], Miriam L Diamond[3] and Liisa M Jantunen[5], [1]University of Toronto, Toronto, ON, Canada, [2]Environment and Climate Change Canada, Egbert, ON, Canada, [3]Department of Earth Sciences, University of Toronto, Toronto, ON, Canada, [4]Trent University, Peterborough, ON, Canada, [5]Air Quality Processes Research Section, Environment and Climate Change Canada, Egbert, ON, Canada. **Atmospheric Sampling for Microplastics: Determining Effective Sampling Methods.**

Microplastics and anthropogenically sourced microparticles (MP-APs), such as synthetic, semi-synthetic and processed natural fibres, are of rising concern globally due to their inherent durability and persistence in the environment. Moreover, they are of high concern due to ingestion and inhalation exposure, and the chemicals associated with their presence. The abundance and distribution of MP-APs in marine environments has been studied extensively. Comparatively, atmospheric transport pathways are understudied. Representative air sampling and quality assurance and quality control (QA/QC) methods are needed to assemble comparable, representative data, especially where collection occurs in remote locations that favour the use of passive sampling methods. We developed QA/QC methods that included blanks and standardized reference materials representative of atmospheric particles based on their morphology. Over one year, diverse collection methods used in atmospheric-related sampling were used in this comprehensive study to compare the efficiency of MP-AP collection in ambient air (for particles 10 μm – 5 mm) and analyzed using Laser Direct Infrared and Fourier Transform Infrared. These sampling methods included two types of bulk deposition samplers; Nipher gauge and a bottle and funnel, a wet precipitation-only sampler, several types of passive samplers; moss bags, polyurethane foam disks, and adhesive strips, and finally, complemented by active high-volume air sampling. Results will be presented.

**Sarah Diane Lawhun**[1], James M Watkins[2], Lars G. Rudstam[2], Toby Holda[2], Kayden C Nasworthy[2], David M Warner[3] and Steve Pothoven[4], [1]Cornell University, Ithaca, NY, USA, [2]Cornell Biological Field Station, Bridgeport, NY, USA, [3]U.S. Geological Survey, Great Lakes Science Center, Ann Arbor, MI, USA, [4]NOAA GLERL, Muskegon, MI, USA. **Shrimply Biased? Lakewide Mysis estimates in Lake Michigan over time and potential bias due to basin differences.**

Long-term Great Lakes monitoring data from USEPA, USGS, and NOAA in Lake Michigan showed a concerning decline in *Mysis diluviana* (Mysis) density and biomass in 2019. Mysis are important prey for many economically valuable Great Lakes fish species and a collapse in their population in Lake Michigan could initiate a parallel decline in the lake's fisheries. The dataset through 2022 is used to assess updated Mysis density and biomass, after the 2020 COVID19 pause, and determine if the decline has continued. Mysis size structure data from 2019-2022 and lakewide biomass and density estimates from 2021-2022 suggest a marginal recovery of the lake's Mysis populations with renewed recruitment. To better interpret long-term lakewide estimates, the same data is used to explore whether a meaningful difference exists between Mysis populations in the lake's northern and southern basins, and whether year to year changes in the spatial extent of mysid collection effort could therefore bias lakewide estimates. The northern basin is much deeper than the southern basin and may support a larger Mysis population. If true, annual estimates based on the USEPA survey may vary simply because different stations are sampled each year. Here we compare the published time series based on straight station averages with estimates that account for the hypothesized differences in abundance by basin. Variability among sites and locations also inform

the number of samples required to estimate abundance with precision. Findings from this comparison will inform future analysis of Mysis data.

Eric Kostecky and **Patrick L. Lawrence**, University of Toledo, Toledo, OH, USA. **Assessing Shoreline Changes at Indiana Dune National Park,Lake Michigan (2013-2018) via LiDAR.**

On February 15th, 2019, Indiana Dunes was elevated to the designation of a U.S. National Park. Along with this designation belongs the credo of the U.S. National Park Service, to conserve such places that are deem ecologically important by such means as will leave them unimpaired for the enjoyment of future generations. In 2019, the water level in Lake Michigan was trending above the long term recorded average, and as a result several locations in the National Park sustained damage due to erosion and inundation. Current water levels are receding, but predictions suggest that fluctuations from low to high periods will becomes more frequent and more severe. Acknowledging that this may be a certain outcome, requires a great understanding of the shoreline morphology within the National Park, especially considering such namesake features as the shoreline dunes. This study uses LiDAR data from an era of below average to a period of elevated water level for five areas of interest within Indiana Dunes National Park, to categorize levels of change in the near shore and beach regions, as well as quantify metrics of beach width change. Resulting in several Areas of Interest containing mixed values of dune elevation loss with some gain. Importantly identifying that Mount Baldy and Central Avenue Beach have majorly experienced dune elevation loss where gains were not seen based on dune migration. Additional findings include the massive inundation of beach area and substantial loss of foredunes at Portage Beach and the token area of beach width gain at Beverly Shores (East).

**Ted J Lawrence**[1,2], Achieng Alfred Otieno[3], Ken Irvine[4] and Zephenia Migeni Ajode[5], [1]African Center for Aquatic Research and Education, Ann Arbor, MI, USA, [2]International Institute for Sustainable Development, Winnipeg, MB, Canada, [3]University of Eldoret, Eldoret, Kenya, [4]IHE-Delft, Delft, Netherlands, [5]African Center for Aquatic Research and Education, Kisumu, Kenya. **The plan to strengthen education and monitoring through a network of field stations on the African Great Lakes.**

The African Great Lakes (AGL) has a dearth of adequate field stations. Many of the research stations in Africa must vie for inadequate resources from their governments or rely solely on "outside" researchers to conduct short-term studies with inadequate financial resources to use their stations. Both approaches reduce the capacity to conduct long-term monitoring and research, but more importantly, a decreased ability to conduct in-field trainings. The consequences of this system reduces capacity of administering education and conducting research. This talk will highlight these challenges and determine the best next steps in the region to do the following: Develop a sustainable model for AGL research stations to enhance education and training; Use this model to cultivate a strong generation of scientists, both in Africa and abroad; Ensure that the research stations on the AGL become world-class hubs, thus enhancing their capacity to train, conduct research and long-term monitoring, and process samples; Create a sustainable business plan to accomplish the above. Without more comprehensive training and education, and reduced capacity to monitor and conduct research, we will find ourselves with too little expertise, too little information, and too little political will to make changes on these critical resources.

**Lauren Lawson**[1], Christopher B Edge[2], Marie-Josée Fortin[1] and Donald Jackson[3], [1]Department of Ecology and Evolutionary Biology, University of Toronto, Toronto, ON, Canada, [2]Canadian Forest Service, Natural Resources Canada, Fredericton, NB, Canada, [3]University of Toronto, Toronto, ON, Canada. **Temporal change in fish biodiversity across highly urbanized watersheds feeding into Lake Ontario.**

The Greater Toronto Area is home to numerous rivers flowing into Lake Ontario. Urbanization has fundamentally altered the hydrology of and aquatic biodiversity in such rivers. Understanding how

urbanization impacts ecosystems through land use change and fragmentation is important to enable integrated management for the health of the region's rivers and their receiving waters of Lake Ontario. Using fish monitoring data from the Toronto and Region Conservation Authority we analyzed how four biodiversity metrics varied within sites over fifteen years in relation to land use change and connectivity. We used the more recently developed temporal beta diversity index (TBI) to assess change in community composition within sites. We find differences in importance of drivers across the four metrics. Overall, we found more gains than losses in species and abundances-per-species across the study region. Certain sites with significant change record shifts to warm water communities and presence of invasive species. Identifying sites with significant change in biodiversity is key for management and restoration. We explore drivers of change and the usefulness of TBI to identify significant change in fish communities within highly structured dendritic river systems in a region with diverse patterns of land use change.

**Sierra Legare** and Marek Stastna, University of Waterloo, Waterloo, ON, Canada. **Modelling under-ice algal growth.**

The relationship between ice physics and algal growth has created an interest in temporal and spatial models of under ice algal growth. Single spatial point models have been developed to describe the bulk temporal evolution of algae populations living under sea-ice but have not been extended to the context of freshwater lakes. While most models have been validated against limited data, no detailed analysis of their multi-year performance or sensitivity to parameters has been published. This poster will present a detailed analysis of a sea-ice model for algal growth [1]. The analysis considers the model's sensitivity to parameters and explores relevant timescales. As an example of the results to be presented, the form of the photosynthetically active radiation forcing function has been shown to determine the frequency at which the algae population responds. With these results in mind, a model adapted to the context of freshwater lakes will be presented. The sea-ice model does not consider the effects of salinity, so the relevant changes concern the seeding of algal blooms. In sea-ice, algae are frozen into multi-year ice to seed subsequent blooms. In freshwater lakes, which may not have multi-year ice, the algal cells must enter a resting state at the bottom of the lake and wait for an upwelling to carry them back up to the ice to seed the subsequent bloom. References: [1] Castellani, G., Losch, M., Lange, B. A., & Flores, H. (2017). Modeling Arctic sea-ice algae: Physical drivers of spatial distribution and algae phenology. *Journal of Geophysical Research: Oceans*.

**Kelsey Leonard**, Lauren Mcelroy and Jade Hill, University of Waterloo, Waterloo, ON, Canada. **Indigenous Water Justice for Climate Action: Indigenous Great Lakes Science Inclusive Education Standards.**

Education standards in Canada and the United States are undergoing review and revision processes to include climate change science. This presentation highlights research findings exploring best practices for including Indigenous science in education standards and how those adoptions promote water justice for climate action. Moreover, the study's preliminary results underscore the need for greater inclusion of Indigenous science for Great Lakes protection. The Intergovernmental Panel on Climate Change 2022 Report recognized colonialism as a driver of the climate crisis. Globally, inherited intellectual legacies of colonialism and, in some instances, ongoing acts of colonialism are embedded within education systems, notably curriculum standards. Addressing the dire impacts of colonialism as an exacerbating factor of the climate crisis can begin in the classroom. Innovative pathways for educational reform are underway across North America. In Canada, the Truth and Reconciliation Commission Report, 94 Calls to Action, emphasizes the need for the inclusion of Indigenous knowledge and teaching methods. The U.S. Office of Science Technology and Policy issued guidance on incorporating Indigenous Traditional Ecological Knowledge across all federal entities, including the Department of Education and other U.S. government science administrative arms. Drawing on these advancements the presentation concludes with lessons learned from case studies of wise practices for Indigenous Great Lakes science inclusion in primary education classrooms.

**Ryan Lepak**[1], Joel C Hoffman[1], Sarah Janssen[2], Sarah Balgooyen[3], Jacob Ogorek[2], Michael Tate[2] and Christopher Yarnes[4], [1]USEPA ORD Great Lakes Ecology and Toxicology Division, Duluth, MN, USA, [2]USGS Mercury Research Lab, Madison, WI, USA, [3]SpecPro Professional Services Contractor at USEPA ORD Great Lakes Ecology and Toxicology Division, Duluth, MN, USA, [4]UC Davis Stable Isotope Lab, Davis, CA, USA. **Exploring contaminant trends in fish to establish a baseline for climate change evaluation.**

Since the late 1970s, Canada and the US have been collecting and archiving Great Lakes fishes for contaminant analyses, which has resulted in rich data archives for many contaminants of mutual and emerging concern. Recently, we were able to sample the fishes collected across all five Great Lakes from the US Environmental Protection Agency - Great Lake National Program Office's Great Lakes Fish Monitoring and Surveillance Program to construct spatiotemporal baselines for new analytes including mercury stable isotopes and per- and poly fluorinated substances. Additionally, we leveraged these archived samples to better understand energetic shifts in the Great Lakes food web by performing a series of ecologically relevant isotope measurements. The temporal pairing of food web and contaminant data will enable us to decipher how ecological and physical stressors, driven by climate change, can alter bioaccumulation of legacy chemicals. Our results do not show obvious correlation with water levels, ice cover, temperature, or contaminant concentrations, but these data help better establish Great Lakes' baselines for future evaluations. Here, we will discuss the changes we observe in fish trends and highlight how these valuable collections could help us better understand changes stemming from climate change, like shifts in erosion and separately nutrient cycling.

**Katrina Lewandowski**[1], Edward Rutherford[2], Donna R Kashian[1], Kishore Gopalakrishnan[1] and Maddie Tomczak[3], [1]Wayne State University, Detroit, MI, USA, [2]NOAA GLERL, Ann Arbor, MI, USA, [3]University of Michigan CIGLR, Ann Arbor, MI, USA. **Identifying the importance of an invasive mussel veliger diet on larval yellow perch growth.**

Invasive dreissenid mussels have profoundly affected Great Lakes ecosystems that support lake fish and fisheries. The mussel populations' exponential growth, high biomass and filtration of plankton and organic material have altered nutrient cycling and flow from nearshore to offshore, and reduced pelagic plankton biomass. Mussel veliger production also has affected community structure of microzooplankton available to first-feeding larval fish. Field studies have documented that some larval fish will consume mussel veligers, but veliger effects on their growth and survival are unknown. In 2021 and 2022, we conducted laboratory experiments to examine effects of veliger consumption on survival, and growth of larval Yellow Perch (*Perca flavescens*). From 5-20 days post-hatch, larvae in each of 5 replicate tanks were offered prey concentrations (250 prey/L) in treatments that varied in their relative proportions of veligers to *Artemia* nauplii. After 20 days, larvae survival and growth were measured, and gut contents recorded. Results indicated that larvae eating a diet high in veligers had reduced survival and lower growth compared to larvae that ate mostly *Artemia* nauplii. Our results suggest that veliger production by invasive mussels lower larvae growth, survival and potential recruitment to older life stages.

Cynthia Collier[1], Brick Fevold[1], **Tim Lewis**[1], Craig Palmer[1], Molly Middlebrook[1] and Louis J. Blume[2], [1]GDIT, Falls Church, VA, USA, [2]EPA Region 5, Chicago, IL, USA. **Assessing the Quality of Non-Direct Data Used in Ecological Restoration Project Planning and Monitoring.**

More data are publicly available than ever before, but if you didn't collect the data yourself, how can you be sure the data are suitable for your intended use? Typically, when collecting data directly, you have control over how the samples are collected, how the measurements are made and to what specifications, and how the results are recorded and stored. When using data someone else collected, known as existing data, secondary data, or non-direct data, you have less control. Existing data may be used in project design, complement data you collect yourself, or to extend the spatiotemporal range of your data to capture historical trends that have been altered by changes in land use or climate. Since the quality of a project's

outcome relies on the quality of all the components used in the process, the quality of existing data must be assessed before it is used. This presentation is based on guidance published in *Application of QA and QC Principles to Ecological Restoration Project Monitoring* (EPA/905/K-19/001). Evaluation of existing data include: locational accuracy, precision/accuracy, representativeness, suitability/comparability of the methods, completeness (does it fully or partially meet your needs), environmental/ecological reasonableness, statistical and graphical examination, inspection of metadata, model parsimony, and the Expected Value of Perfect and Imperfect Information. This effort is funded under an EPA contract in support of the Great Lakes Restoration Initiative.

**Jingjing Li**[1], Robert Michael McKay[2], Runbing Xu[3] and Xuexiu Chang[4,5], [1]Kunming University, Kunming, China, [2]Great Lakes Institute for Environmental Research, University of Windsor, Windsor, ON, Canada, [3]Yunnan University, Kunming, China, [4]College of Agriculture and Life Sciences, Kunming University, Kunming, China, [5]University of Windsor, Windsor, ON, Canada. **Variation of community structure of phytoplankton and metazoan zooplankton associated with a *Microcystis* bloom.**

Globally, blooms of *Microcystis* and other cyanobacteria lead to impairment in lake ecosystems. Co-occurring plankton is recognized as one of the most sensitive targets negatively influenced by *Microcystis* blooms. However, our understanding of how co-occurring plankton communities are impacted by blooms is limited. To assess bloom impact, we investigated the spatial-temporal variation of the plankton community in Lake Dianchi, the largest lake in southwest China and which has been stressed by recurring blooms of *Microcystis*. We found that *Microcystis* were dominant amongst cyanobacteria whereas chlorophytes and diatoms were most abundant amongst eukaryotic phytoplankton. Rotifers and small-body cladocerans were dominant among metazoan zooplankton in summer (blooming season) whereas large-body cladocerans were dominant in winter (lower *Microcystis* density). The composition of the phytoplankton and metazoan zooplankton communities relied significantly on *Microcystis* abundance, especially in summer. Furthermore, variables of *Microcystis* relative biomass explained the highest variation of phyto-, metazoan zooplankton communities in both summer (27%) and winter (36%). Among all phyto-, metazoan zooplankton taxa, *Microcystis* abundance was correlated strongly to abundance of chlorophytes and cladocerans. Our study enhances the understanding of the influence of *Microcystis* blooms on plankton communities, knowledge that will inform lake management strategies.

**Emily M. Liljestrand**[1], James R. Bence[1] and Jonathan J. Deroba[2], [1]Michigan State University, East Lansing, MI, USA, [2]Northeast Fisheries Science Center, Woods Hole, MA, USA. **Application of State-space Stock Assessment Models to Laurentian Great Lakes Fisheries.**

State-space stock assessment models have been increasingly employed to manage marine species in Europe, Canada, and the United States. The model structure allows for more process variability (resulting from natural variation in the system) and observation error (factors leading to differences between what is measured and what is true) to be quantified than previously employed models. The state-space structure can estimate the variance of several stochastic life history and fishery processes like recruitment, mortality, and catchability, which could better inform management decisions and model projections. However, state-space stock assessment models have principally been applied in cases where informative fisheries-independent data are available. Many Laurentian Great Lakes stocks such as lake whitefish (*Coregonus clupeaformis*), lack reliable survey information and depend on fisheries-dependent data like catch-per-unit-effort for a trend in abundance. We built a novel state-space stock assessment model and fit it to lake whitefish catch and effort data in the 1836 Treaty-ceded waters of the Great Lakes. We present model estimates of time- and age-varying catchability and how abundance, biomass, and fishing mortality trends compare to results from methods currently used in treaty-water management that do not directly estimate process and observation error variances. This modeling framework may be applied to other stocks in the Great Lakes or other fisheries which similarly rely exclusively on fisheries-dependent data.

**Juliana Lisuk**, Inland Seas Education Association, Suttons Bay, MI, USA. **Fostering Stewardship Through Hands-On Experiences: ISEA's Approach to Great Lakes Literacy.**

Inland Seas Education Association (ISEA) is a non-profit organization based in Suttons Bay, MI on the shores of Lake Michigan. Since 1989, ISEA has provided hands-on educational experiences aboard traditionally rigged tall ship schooners, along the shores of the Great Lakes, and in local rivers, streams, and wetlands, employing a place-based approach in their programmatic design. ISEA provides non-formal educational experiences that align with school standards and explore Great Lakes ecology. These programs model systems thinking and provide the opportunity to build positive connections to the Great Lakes, both of which are foundational aspects of fostering a stewardship ethic. Over the past 30+ years, ISEA has reached over 150,000 participants across all five Great Lakes. Using a schooner as an educational platform provides ISEA the unique ability to bring programs to participants' home waters. ISEA believes that place-based, hands-on education plays a key role in sustaining the Great Lakes for future generations and aims to inspire curiosity, passion, and stewardship in people of all ages through their work.

**John Liu**, Ontario Ministry of Environment, Conservation and Parks, Toronto, ON, Canada. **High Resolution Regional Climate Modelling over Ontario and the Canadian Great Lakes Basin.**

This presentation will provide an overview of the fundamentals of climate change and climate modelling and a summary of the high-resolution regional climate modelling the Ontario Ministry of the Environment, Conservation and Parks (MECP) has overseen for Ontario and the Great Lakes Basin in support of climate change adaptation. Due to the coarse resolution of global climate models (GCMs) these models are unable to resolve geophysical features at regional/local scales, such as the Great Lakes and the Niagara Escarpment which have significant impacts on Ontario's local climate. However, most adaptation practices are implemented at the local/community scale and need climate information at higher resolution. To address this climate information gap, the Ontario government has refined the climate information from the global scale models (i.e., 100's of kilometers) down to the local scale (i.e., 10's of kilometers) using state-of-the-science downscaling techniques. Terabytes of Ontario-specific high resolution regional climate projections have been developed and disseminated via climate data portals which provide both intuitive visualization to all users (the general public and policymakers) and extensive data downloading for scientists/engineers for their risk/vulnerability assessments. This presentation will conclude with a brief overview of the expected climate changes over the Canadian Great Lakes Basin, and a brief live demonstration of the most up-to-date Ontario Climate Data Portal if time permits.

**Aislin Livingstone**, DataStream, Toronto, ON, Canada. **Introducing Great Lakes DataStream – an open access platform for sharing water quality data.**

Across the Great Lakes basin, governments, communities, watershed groups and academics are leading a massive effort to generate valuable data and information required to track and understand freshwater health. The distributed nature of these monitoring efforts makes it challenging to connect and share data in ways that are useful to communities and decision-makers at local, regional, and transboundary scales. Many open access online tools and resources have been developed over the years to address the perennial challenge of coordinating Great Lakes data. In this presentation, we will explore how Great Lakes DataStream – a powerful online platform for sharing water quality data – is contributing to a growing open data system of systems and helping to advance collaborative water stewardship. Great Lakes DataStream was officially launched on September 28, 2022, during the Great Lakes Public Forum and already has over eight million data points from more than 65 datasets.

**Chelsea Lobson**, Lake Winnipeg Foundation, Winnipeg, MB, Canada. **Community monitoring to collect high-quality phosphorus loading data in the Lake Winnipeg Watershed.**

Lake Winnipeg, the world's 10th largest freshwater lake, has had an increase in blue-green algae blooms caused by an increase in phosphorus loading from the watershed. Frequent, responsive phosphorus monitoring which captures major flow events is required to accurately calculate phosphorus loads and exports. With accurate data, we can identify where phosphorus is coming from in the watershed and track how it is changing over time. Launched in 2016, the Lake Winnipeg Community-Based Monitoring Network (LWCBMN) is a network of volunteers and watershed partners collecting water samples for phosphorus testing from over 100 Water Survey of Canada flow stations in the watershed. Volunteers and partners live near their sites and can sample frequently and responsively to flow changes. This nimble network has proven to be useful for capturing the impacts of unpredictable, extreme precipitation events which are becoming more frequent with climate change. By partnering with local volunteers, LWCBMN is able to sample at many points within larger drainage areas to identify phosphorus hotspots – localized areas that contribute more phosphorus to waterways than other areas. Phosphorus hotspots identified by the program are used to target resources and action where they will have the greatest impact on phosphorus loading to Lake Winnipeg.

**Luke C. Loken**[1], Donald B Bonville[2], Stephanie P Kula[3], Greg Koltun[3], Dale M Robertson[1], Erin E Bertke[3], Matthew W. Diebel[1] and Matthew J. Komiskey[1], [1]U.S. Geological Survey, Upper Midwest Water Science Center, Madison, WI, USA, [2]U.S. Geological Survey, New York Water Science Center, Troy, NY, USA, [3]U.S. Geological Survey, Ohio-Kentucky-Indiana Water Science Center, Columbus, OH, USA.
**Trends in phosphorus loading since 2011 in 24 U.S. Great Lakes tributaries.**

Largely through conservation and management activities, extensive effort has been made in the Great Lakes region to protect and improve water quality, yet tracking progress in streams and rivers remains a challenge. Phosphorus loading to the Great Lakes is of primary interest due to associations with eutrophication and harmful algal blooms. Using continuous flow records and monthly discrete water samples, fluxes of total phosphorus (TP) and dissolved orthophosphate (DP) for 24 U.S. Great Lakes tributaries for the period of 2011 to 2020 for using Weighted Regressions on Time, Discharge, and Season (WRTDS) with Kalman filtering. Changes in fluxes over this period were estimated using flow-normalization with bootstrapped confidence intervals. Results indicate that flow-normalized TP fluxes likely (posterior mean probability > 0.9) decreased at 16 of 24 sites and increased at one site. In contrast, fluxes of DP likely decreased at 8 sites and increased at 1 site. These results indicate that tributary loading of phosphorus to the Great Lakes has likely decreased in the last decade after normalizing for variation in discharge. However, greater discharge toward the end of the decade in 20 of the 24 tributaries has offset much of those estimated water quality improvements as actual TP and DP loads decreased in only 9 and 6 sites, respectively. This study demonstrates an approach for describing changes in water quality across the Great Lakes Basin, which highlights the ongoing need for long-term monitoring to assess whether management actions are having beneficial effects.

**Yer Lor**[1], Marissa Kaminski[1], Stephen Spear[1], Katy Klymus[2], Cathy Richter[2], Patrick Kroboth[2], Duane Chapman[2], Christopher Merkes[1] and Nathan Thompson[2], [1]U.S. Geological Survey, La Crosse, WI, USA, [2]U.S. Geological Survey, Columbia, MO, USA. **What do Black Carp (*Mylopharyngodon piceus*) eat? Can metabarcoding aid in the identification?.**

Invasive species can be detrimental to the environments they invade and outcompete native species. Increased captures of wild Black carp (*Mylopharyngodon piceus*), an invasive molluscivore, have raised concerns of these species impacting native imperiled unionid mussel populations. Poulton et al. (2019) examined the digestive contents of over 100 fish captured from lentic and lotic habitats, but visual identification can be extremely challenging. The use of genetic identification and metabarcoding may allow for a more efficient and consistent way to identify Black carp diets. We use DNA metabarcoding to identify diet contents of wild-caught Black carp and compare them with the visual identification of the diets. We extracted DNA from gut contents of 58 wild-caught black carp preserved in ethanol and used two unionid metabarcoding

assays that target COI and ND1 genes to identify unionid mussel species. We also used a general macroinvertebrate marker to identify other prey species consumed by Black carp. We will present the comparison between prey species identified with metabarcoding and visual identification.

**Michael Lowe**[1], Katy Dawson[1], Andrew M Muir[2], Tom Binder[3], Ben Michaels[4] and Bill Mattes[4], [1]USGS - Hammond Bay Biological Station, Millersburg, MI, USA, [2]Great Lakes Fishery Commission, Ann Arbor, MI, USA, [3]Michigan State University, Millersburg, MI, USA, [4]Great Lakes Indian Fish and Wildlife Commission, Odanah, WI, USA. **Running the gauntlet: effects of legacy mining wastes on lake whitefish (*Coregonus clupeaformis)* recruitment.**

Buffalo Reef is currently the focus of large-scale mitigation efforts being lead by multiple tribal, state, and federal agencies. The reef was once recognized as one of the primary producers of lake whitefish in the region. However, the littoral drift of legacy mining wastes (known locally as "stamp sand") deposited on the shoreline more than 100 years ago began impacting critical lake whitefish habitats in the early 1990s. Since that time, there has been a severe reduction in both juvenile lake whitefish recruitment and fisheries landings that does not match lake-wide trends. This paper synthesizes the results of multiple, ongoing studies to better understand how stamp sand effects 1) embryo fertilization and development, 2) hatching success, 3) larval swimming performance and 4) several metrics describing the relative value of the nursery habitat adjacent to Buffalo Reef. Yet, despite an appreciable effect at each stage, there is also evidence of recent recruitment at Buffalo Reef that, taken together, suggests some portion of the lake whitefish population has adapted to the potentially stressful environment created by the stamp sand.

**El Lower**[1], Rochelle Sturtevant[2] and Joris Van Zeghbroek[3], [1]GLANSIS, Michigan Sea Grant, Ann Arbor, MI, USA, [2]NOAA/GLERL - GLANSIS, Michigan Sea Grant, Ann Arbor, MI, USA, [3]Michigan Sea Grant, Ann Arbor, MI, USA. **Metaphors Be With You: Alternative Frameworks for Communicating about AIS.**

Environmental researchers and science communicators are increasingly recognizing the importance of appropriate metaphors in sharing their work – but what happens when some of the most commonly-used metaphors in the field are no longer considered best practice? Communicating about invasive species has frequently relied on military and nationalist language to convey risk and inspire public concern about environmental health, but an increasing number of studies have shown that these frameworks have significant rhetorical drawbacks – and can even undermine their own intended goals. This talk will focus on alternate metaphors for communicating about aquatic invasive species, from health-based frameworks to hitchhikers, that might serve a better role in classrooms, outreach material, and beyond.

**Chris Lowry**[1], Nicole Bin[2] and Jenny Soonthornrangsan[3], [1]University at Buffalo, Buffalo, NY, USA, [2]Pontificia Universidad Católica de Chile, Santiago, Santiago, Chile, [3]TU Delft, Delft, Delft, Netherlands. **Connecting the pieces between climate models and coupled groundwater-surface water interactions.**

Challenges arise when navigating connections between climate and hydrologic models to forecast future water availability. These challenges can be due to spatial/temporal resolution, data availability, and model architecture. As a hydrologic community, we are asked to answer bigger societal questions. However, our models can fall short of these goals. The research presented here reviews past efforts to link climate and hydrologic models. Then it applies these lessons to a fully coupled groundwater/surface water model in the lower Great Lakes driven by down-scaled climate models. Results from the literature show trends in linking climate to hydrologic models to help point the hydrologic community toward forward progress. Results from our numerical modeling show the impacts on groundwater-surface water interactions from the distribution of 27 climate models and two scenarios (SSP2 4.5 and SSP2 8.5). Hydrologic results driven by climate projections in both scenarios show a higher uncertainty in precipitation than in temperature

forecasts. Aquifer storage is projected to increase in half the ensemble members of SSP2 4.5, while storage increases in all members of SSP5 8.5. Ensembles from the same climate change scenario can lead to very different results, particularly in SSP2 4.5, where precipitation projection differs greatly. Owing to the cascading effects of these climate models, the hydrologic community needs to consider using multiple models to forecast the distribution of potential impacts of climate change toward better management of water resources.

**Al Lu**[1], Josef D. Ackerman[2] and Todd Morris[3], [1]University of Guelph, Guelph, ON, Canada, [2]Department of Integrative Biology, University of Guelph, Guelph, ON, Canada, [3]Fisheries and Oceans Canada, Burlington, ON, Canada. **Buffering success: assessing the effect of riparian vegetation buffers on juvenile unionid mussel habitats.**

Juvenile unionid mussels experience mortality in poor porewater conditions (low hyporheic conductivity, low dissolved oxygen (DO), high ammonia, and high cyanobacteria abundance), which can be caused by land-use changes. Habitat quality and mussel assemblages were compared between mussel beds in intact buffer sites (buffers > 30 m; n = 4) vs. fragmented buffer sites (buffers < 20 m on one or both banks; n = 4) in the north and east branches of the Sydenham River, Ontario. High quality habitats were found to be strongly correlated with high hyporheic conductivity and consequently, low quantities of fine sediments. In the east, habitat quality was higher in intact buffer sites, with significantly higher DO, diatom and chlorophyte concentrations and significantly lower ammonia and cyanobacteria. This assessment was supported by the distribution of adult mussels, which were more abundant in higher quality habitats. Unfortunately, the north branch exhibited higher fine sediments due to its surficial geology, which precluded the discrimination between riparian buffer states, but included many silt tolerant unionids. The distribution of juvenile mussels was consistent with habitat quality differences between buffer states, but low sample size (17 in intact vs. 2 in fragmented) precluded statistical analysis. Results indicate that riparian buffers can be effective at maintaining juvenile unionid habitats if they are sufficiently large to prevent excess fine sediment.

**Andrew Luessenhop**, In-Situ, Fort Collins, CO, USA. **What is needed for development of an AI algal bloom prediction algorithm.**

Remote sensing and ground-truth sensor technology must continually evolve to provide the robust datasets needed for modeling and prediction of significant water-related events that could be harmful to health of many species. The Cleveland Water Alliance testbed program has provided a substantial opportunity to continue developing algae-centric algorithms, expanding scientific knowledge of bloom spread in the region through public data dissemination. In-Situ, Inc. and BiOceanOr developed a partnership in early 2022 surrounding the prediction of HABs in Lake Erie. Through the combination of satellite data, ground-truth sensors as part of a smart watershed, and artificial intelligence, potential algae bloom growth and effects can be determined for more effective response and decision-making. The sensor package provided by In-Situ included physical parameters such as conductivity, pH, and dissolved oxygen, as well as fluorometers for measuring chlorophyll, blue-green algae, and fluorescent dissolved organic matter. Algorithms developed by BiOceanOr using In-Situ sensors and external satellite data are currently predicting algae blooms and dissolved oxygen fluctuations in other regions of the world and this innovation will continue to be expanded across the Great Lakes Region in 2023.

**Gabriella Lükő** and Peter Torma, National Laboratory for Water Science and Security, Budapest University of Technology and Economics, Faculty of Civil Engineering, Department of Hydraulic and Water Resources Engineering, Budapest, Hungary. **Comprehensive analysis of model parameters and wind forcing for simulating hydrodynamics of a large shallow lake.**

We aim to set up a well-validated hydro- and thermodynamic model for the large and shallow Lake Balaton, which can be used for forecasting. In shallow lakes, wave-affected surface and bottom boundary layers can overlap during windy conditions, resulting in complex flow fields. In contrast, only weak thermal stratification can develop during calm periods, which typically breaks up during nighttime, resulting in a clear diurnal cycle. We applied the FVCOM model for numerical simulations and carried out current and temperature measurements at onshore and offshore locations. We force the model with a spatially varying wind field that incorporates the effect of internal boundary layer development over the surface, leading to increasing wind stress along the fetch. We show that inhomogeneous wind forcing is essential to model water level fluctuations accurately and improve current directions. To reliably simulate the thermal structure besides currents, a sensitivity analysis is performed for model parameters, including air-water heat exchange parameters, light extinction coefficient, and turbulence model parameters, like background mixing and wave-induced mixing. We compare modeled and observed currents, temperatures, and thermal structures using the potential energy anomaly for the latter one. The multi-objective calibration requires a large set of simulations that covers the wide parameter space to find an optimal parameter set and avoid equifinality.

**Yifan Luo**, Andrew Gronewold, Hannah Paulson, Maegan Muir and Justin Huber, University of Michigan, Ann Arbor, MI, USA. **Apply the Large Lake Statistical Water Balance Model to Reduce Uncertainty in Great Lakes Water Balance Components.**

The Laurentian Great Lakes and St. Lawrence River basin comprises the largest freshwater system on Earth, containing about one-fifth of the world's surface fresh water. However, the Great Lakes basin has recently experienced some rapid shifts between high and low in some water balance components. To resolve regional water budget in the Great Lakes over an extended historical period and provide insight moving forward in our changing climate, we incorporated the Large Lake Statistical Water Balance Model (L2SWBM) to adequately quantify uncertainty and reconcile discrepancy between model- and measurement-based estimates from various datasets. L2SWBM contextualized and reduced uncertainty while closing the water balance over consecutive historical periods. Using observed and modeled data of water balance components through historical records, the L2SWBM can be used to iteratively solve the coefficient values and estimate a range of reasonable uncertainties in individual components that are faithful to the water balance. After applying the L2SWBM, uncertainty was significantly reduced by approximately 10-40% depending on original estimates. Therefore, our approach provides a valuable tool for addressing the challenges of uncertainty in water balance components, and allows for a more accurate understanding of water budget in the Great Lakes, which can be used to improve our understanding of climate change signals in historical record, anticipate plausible future water balance scenarios, and support water resource management and policy-making.

# M

**John Ross MacDonald**[1], Nicholas Riddick[1] and Francine McCarthy[2], [1]Brock University, St Catharines, ON, Canada, [2]Brock University, St. Catharines, ON, Canada. **Paleolimnological evidence of Middle Woodland settlement 2000 years earlier than archeological evidence suggests.**

The water level history of Lake Erie is well constrained by paleolimnological evidence, for example by Lewis et al (2012): Lowstand 12270 to 6830-7860 cal BP; Nipissing Flood Highstand 6830-7860 to ~3770 BP; and subsequent Lowstand. The Fitzgerald archeological site, dated by Parker (1997) to the Early Woodland Period 2,550-1,950 BP (600BC – 1 AD) based on lithic artifacts, co-existed with the highstand that ended 2000 years earlier. Sediment cores from Cates Creek, 150 m from and 3 m below the elevation of the Fitzgerald Site, were analysed for pollen, plant macrofossils, sedimentology, and geochemistry, and dated using radiocarbon and pollen stratigraphy. All the analyses show consistent segmentation into two depth ranges, 100-50 cm and 50-0 cm, which correspond to two time periods for the locality, or chronotopes,

which we call *Manoomin Cove*, 4850 – 3650 cal BP, and *Cates Creek*, since 3650 BP. Macro- and microfossils of wild rice in the Manoomin Cove unit suggest a raison-d'etre for the settlement along paleo-shoreline of Lake Erie, and chert knappings establish the contemporaneous presence of gatherers. Physical (grain size) and geochemical (ITRAX microXRF) analyses record a change in depositional environment from a wild rice marsh-fringed cove to a small fluvially dominated lagoon about 3, 650 BP, when erosion of the Lyell-Johnson Sill caused lake level to fall relatively suddenly. Our findings have possible implications for the earliest occurrence of Early Woodland artifacts along the north shore of eastern Lake Erie

Robert Schwefel[1], **Sally MacIntyre**[2], Alicia Cortes[3] and Steve Sadro[3], [1]Leibniz-Institute of Freshwater Ecology and Inland Fisheries – IGB, Berlin., Germany, [2]University of California at Santa Barbara, Santa Barbara, CA, USA, [3]University of California at Davis, Davis, CA, USA. **Oxygen depletion and sediment respiration in ice-covered arctic lakes.**

Processes regulating the rate of oxygen depletion are responsible for winter hypoxia and the accumulation of greenhouse gases in seasonally ice-covered lakes. Here we investigate the oxygen budget of four arctic lakes using high-frequency data during two winters in three shallow lakes (9-13 m maximal depth) and during four winters in 26 m deep Toolik Lake. In-situ data were complemented by incubation experiments measuring sediment metabolism. Volume-averaged oxygen depletion measured in situ was independent of water temperature under ice and on the duration of the ice-covered period. Oxygen depletion varied with lake morphometry with higher loss rates in smaller lakes with their larger ratio of sediment area to volume. Average values were between 0.2 and 0.38 g $O_2$ $m^{-2}d^{-1}$ in the shallow lakes, and between 0.03 and 0.14 g $O_2$ $m^{-2}d^{-1}$ in Toolik Lake. Rates decreased to ~20%-50% of the initial values in late winter in the shallow lakes. Lower *in situ* oxygen depletion than in sediment incubation measurements points toward increasing anoxia in the lower water column depressing rates of loss. In Toolik lake, oxygen loss during early winter was less in years when snow cover was minimal. Penetrative convection occurred, which could then mix downwards oxygen produced by photosynthesis or excluded with ice formation. Values of these terms exceeded photosynthesis measured in sediment incubations. Consideration of time-dependent processes that moderate incoming irradiance and oxygen transport and concentrations are needed when modeling under ice oxygen. .

Wencai Zhou[1], **Sally MacIntyre**[1], John Michael Melack[1], Pedro M. Barbosa[2], Joao H. F. Amaral[3] and Alicia Cortes[4], [1]University of California at Santa Barbara, Santa Barbara, CA, USA, [2]Université du Québec à Montréal, Quebec, QC, Canada, [3]University of Florida, Gainesville, FL, USA, [4]University of California at Davis, Davis, CA, USA. **Hydrodynamic modeling of stratification and mixing in shallow, tropical floodplain lakes.**

Floodplain lakes are widespread and ecologically important throughout tropical river systems. Data are rare that describe how temporal variations in hydrological, meteorological and optical conditions moderate stratification and mixing in these shallow tropical lakes. Using time series measurements of meteorology and water-column temperatures from 17 several day campaigns spanning two hydrological years at a representative Amazon floodplain lake, we calculated surface energy fluxes and thermal stratification, and applied and evaluated a 3-dimensional hydrodynamic model. Diurnal heating with strong stratification and nocturnal mixing were common, yet once the lake was deeper than 2 m, convective mixing only intermittently extended through the whole water column. Diurnal thermoclines formed in the day, with simulations indicating that they tilted creating lake-wide differences in near-surface temperatures and mixed layer depths. As winds declined or changed direction during cooling, modeling indicated that lateral advection of warm water sustained stratification constraining the depth of convective mixing despite heat losses up to -450 W $m^{-2}$. The persistent stratification enables hypoxia and accumulation of methane and carbon dioxide in deeper water. Near-surface dissipation rates were enhanced during heating. Model improvements include incorporating the similarity scaling that can capture such effects.

**Ceilidh Mackie**[1], Rachel Lackey[1] and Jana Levison[1,2], [1]University of Guelph, Guelph, ON, Canada, [2]Morwick G360 Groundwater Research Institute, Guelph, ON, Canada. **Groundwater chloride in the Great Lakes Basin – geospatial analysis and ensuing field investigations in hot spot area.**

Increasing urbanization, combined with a requisite for maintaining winter road safety, often leads to excessive road salt application and subsequent release of inordinate chloride into the local environment. The northern location and climate of the Great Lakes Basin renders it particularly prone to this occurrence. Streams and lakes in the basin routinely exceed established guidelines for chloride. However, in recent decades, elevated concentrations have also been observed in urban Ontario groundwater. While the role of surface runoff in elevated surface water chloride concentrations is more well understood, the contribution from groundwater remains poorly investigated. To do this, historical chloride concentration data (groundwater and surface water) from monitoring programs in Ontario has been compiled. Using this information, relationships were examined between groundwater and surface water chloride concentration data, land use, and hydrogeological features using geospatial analysis to target hot spots, or vulnerable areas, necessitating further in-situ analysis and targeted road salt management. This analysis highlighted the Western Lake Ontario Basin as an area of concern. Detailed field investigations in the Credit River watershed (within this area) are currently underway to address knowledge gaps and further the understanding of how groundwater receives chloride and ultimately delivers it to surface waters in the watershed. Project outcomes will support recommendations for future road salt best practices and policies in the region.

**Chandra Madramootoo**, Genevieve Grenon and Miranda Xiao, McGill University, Montreal, QC, Canada. **Improved Water Management Systems to Reduce Agricultural Non-Point Source Pollution in Lake Simcoe.**

The Lake Simcoe watershed north of Toronto is approximately 3,400 km$^2$ and represents one of the largest freshwater bodies entirely within the province of Ontario. It is a multiple use watershed with large tracts of green space, forest cover, and natural wetlands. The watershed and lake are very rich in terrestrial and aquatic species, flora and fauna and various ecological habitats. However, there are many stressors that may be affecting the ecology of the watershed and lake, such as deforestation, municipal expansion, wetland shrinkage and pollutants from municipal, industrial and agricultural sources. Agriculture accounts for about 36% of the watershed. A unique feature of the agricultural lands is that they are located on organic soil deposits. One such area is the Holland Marsh, which drains to Lake Simcoe via the West Holland River. These low-lying peatlands are intensively cultivated with high-value vegetable crops. Runoff from the agricultural muck soils impairs lake water quality, due to excess nitrogen and phosphorus fertilizer applications that could lead to algal blooms and eutrophication. This presentation will focus on the application of controlled drainage at the field scale and agro-environmental best management practices, in support of the Lake Simcoe phosphorus reduction strategy.

**Mani Mahdinia**[1], Andre R. Erler[2], Yiling Huo[3] and W. Richard Peltier[4], [1]University of Toronto, Aquanty, Toronto, ON, Canada, [2]Aquanty, Waterloo, ON, Canada, [3]PNNL, Richland, WA, USA, [4]University of Toronto, Toronto, ON, Canada. **Overcoming challenges in the representation of large lakes in regional climate models.**

While large lakes, a major component of the North American (NA) landscape, can affect the water cycle and modulate temperatures in surrounding regions, some current lake models tend to produce unrealistically low lake-effect precipitation or large ice cover. The goal of this work is to compare the results produced from different lake models / different setups, to determine which produce the results closest to reality. We use the Weather Research and Forecasting (WRF) model, a widely-used regional climate model, forced by the ERA5 reanalysis to study the Laurentian Great Lakes; the Great Slave and Great Bear Lakes of the Northwest Territories; and Lakes Winnipeg and Winnipegosis. The lake models are the default model, Flake (a widely used empirical model) and GL25 (a recent and physics-based model). While we show

which model performs better – depending on the location and season, we also address the effects of model resolution, vertical eddy diffusivity and lake stratification on the outcome. Initial results suggest that enhancing any of these parameters in fact produces better simulation results in terms of the temperature-depth profiles, near-surface temperatures and ice cover. The outcome is a model / configuration setup that best represents reality.

**Jasmine Mancuso**[1], Ashley Burtner[1], Andrew Camilleri[1], Kelly McCabe[1], Christine Kitchens[1], Duane Gossiaux[2], Glenn Carter[1], Reagan M. Errera[2] and Casey M Godwin[1], [1]Cooperative Institute for Great Lakes Research, University of Michigan, Ann Arbor, MI, USA, [2]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, USA. **Assessing the effects of Detroit River inflow on Western Lake Erie bloom conditions along a transect.**

Following improvement of the harmful algal bloom impairment in the 1970s, Lake Erie began experiencing re-eutrophication in the 1990s, largely credited to increased agricultural dissolved P loads. Western Lake Erie, the most impacted basin, is subject to high nutrient input from the Maumee River and more-dilute, but large discharge from the Detroit River. Our study aims to understand how water quality parameters and the phytoplankton community change along a ~31 km-transect originating at the Detroit River mouth and terminating ~10 km northeast of the Maumee River mouth. At 7-8 locations along the transect, we collected water quality measurements and used a FluoroProbe to determine algal community composition. Sampling occurred monthly May-October in 2021 and 2022. 2021 data showed that transect patterns were not consistent through time; however, chlorophyll *a*, microcystin, particulate organic carbon and nitrogen, suspended solids, and total P generally increased along the transect. During both years, algal biomass increased with distance from the Detroit River (more drastically in later months). However, in 2021, diatoms consistently remained a substantial portion of the community, whereas in 2022, cyanobacteria largely replaced diatoms in August-September. This difference may be explained by differences in precipitation, as the Lake Erie basin experienced more precipitation in 2021 than 2022, particularly in June-October. Further exploration of data will help elucidate the effect of Detroit River inflow on conditions in Western Lake Erie.

**Nicholas E. Mandrak**, Department of Physical and Environmental Sciences, University of Toronto Scarborough, Toronto, ON, Canada. **Taxonomy of Ciscoes (*Leucichthys* spp.) in the Laurentian Great Lakes: Current Status and Path Forward.**

Historically, the taxonomy of the genus *Coregonus* has been considered problematic due extensive morphological variation in both space and time and, more recently, due to ambiguous results of genetic analyses. In 1949, Svärdson referred to this as the "coregonid problem" that, recently, has been considered a myth by others. In 2016, Eshenroder et al. examined the "coregonid problem" of cisco taxonomy n the Laurentian Great Lakes. In 1929, Koelz recognize nine species and seven subspecies of ciscoes in the Great Lakes. Since then, some species have been lost, and other forms (20+) have been identified, but without formal taxonomic description. Genetic analyses have largely further confused, rather than resolved, cisco taxonomy. In an attempt to better understand the taxonomy of ciscoes in the Great Lakes, the Great Lakes Fishery Commission hosted a symposium in 2022. The American Fisheries Society (AFS) Names Committee was in attendance to determine, based on the 15 presentations, what Great Lakes cisco taxonomy should be used in its forthcoming 2023 AFS names of North American fishes book. Based on multiple lines of evidence presented during the symposium, the Committee accepted seven species, listed in the 2013 book, and *C alpenae* and *C. nipigon*, as valid, and recognized that there are likely additional species yet to be formally described. Recent genomic analyses provide promising insight into cisco taxonomy; however, a taxonomic revision of Great Lakes ciscoes is required based on comprehensive morphological and genomic datasets that include all forms in all lakes.

**Nathan F Manning** and Laura T. Johnson, Heidelberg University NCWQR, Tiffin, OH, USA. **When to Collect and How to Share: Insights from the Heidelberg Tributary Loading Program.**

The Heidelberg Tributary Loading Program (HTLP) has collected water quality data for rivers in Ohio and southeast Michigan for nearly fifty years. Over the decades we have learned many lessons about the operation of a large-scale, high-frequency monitoring program, and have worked to improve both our efficiency and the accuracy of our data. In this talk we will discuss several of those lessons and how they can help in the establishment of successful monitoring programs in other aquatic systems. A recent focus has been on sampling regimes, the use of different load-estimator packages, and how to determine an acceptable level of precision and bias in the resulting estimates. The results of this study can help inform the design of a sampling program, the use of publicly-available estimators, and even the selection of underlying algorithms within the estimator suites. Public data sharing, including collaborative efforts and the proper citation of the underlying data in scientific literature, has also been a focus of our lab in recent years. Because we have such large, publicly available data sets, it is important to know who is accessing the data, and how it is being used, and we have made significant changes in both how our data is stored and how it is cited. We feel that we are in a unique position to help make projects like the Saginaw Bay Monitoring Consortium successful, and hope to see other large-scale monitoring projects build on our foundation.

**Laura Manns**, Ohio Wetlands Association, Columbus, OH, USA. **Integrating Project WET, Water Quality, Wetlands, GIS and H2Ohio into the 7th Grade Curriculum.**

The Ohio Wetlands Association was awarded an OEEF mini grant which sought to create an authentic, place-based learning opportunity for the students of St. Brigid of Kildare School in Dublin, OH. The basis of this project was Project WET, with 14 lessons being integrated into the 7th grade curriculum, over four content areas. The goal was to foster a deeper understanding of science concepts related to fresh water and the social context in which they occur. Project concurrently met Ohio Learning Standards 7.ESS.1, 7.ESS.2, 7.LS.2 and 7.W.1 and introduced surface water quality issues currently being addressed in OH, wetlands, GIS, and H2Ohio. The four content areas included were science, language arts, art, and religion. Forty students participated in the 7-week module. Outcomes included: educators trained in Project WET & Healthy Water, Healthy People; stormwater workshop led by Franklin Soil and Water Conservation District, wetland field trip led by Metro Parks; creation of a interactive digital wetland map through a collaboration between FSWCD & Metro Parks, a watershed mural with a wetland focus created by students and displayed at the school to educate the student body on current watershed issues and contains a digital interface which is accessed through a QR code; virtual wetland field trip was created by the USDA NRCS. Students decided to raise enough funds to install a well in a village Africa and held 3 separate fundraising events, raising a total of $1,610; providing a water well, pump, family wash station, and two hand washing station through Catholic Relief Services.

**Laura Manns**[1] and Lorraine Krzyzewski[2], [1]Ohio Wetlands Association, Plain City, OH, USA, [2]Columbus Division of Water, Columbus, OH, USA. **Collaborative Watershed Education in 9th Grade Physical Science.**

Environmental education can successfully be introduced into the formal education classroom by aligning state learning targets with relevant, authentic place-based learning opportunities. Environmental professionals can enhance student learning by sharing their knowledge and expertise, also reducing educator preparation time. A series of three lessons was implemented in the 9th grade science classrooms at Bishop Watterson High School in Columbus, OH. The lessons concurrently met state standards and, through a collaboration between educator and the Columbus Division of Water Watershed Manager, allowed for the inclusion of information on local drinking water sources, treatment and potential career opportunities. Finally, lessons introduced concepts including changes in Ohio's water cycle, projected climate adaptation costs, efforts by H2Ohio to ensure safe, potable water for all Ohioans, and actions students can take at the local watershed level to have a positive impact.

Britney Bourdages[1], **Stafford Maracle**[2], Orianne Tournayre[2], Stephen C Lougheed[2], Abraham Francis[3], Kayla Sunday[1], Jeffrey J Ridal[4] and Matthew JS Windle[4], [1]Mohawk Council of Akwesasne, Akwesasne, ON, Canada, [2]Queen's University, Kingston, ON, Canada, [3]Cornell University, Ithica, NY, USA, [4]St. Lawrence River Institute, Cornwall, ON, Canada. **Gettin' Fishy With It: new approaches made possible through Indigenous partnerships.**

Global freshwater ecosystems rank as one of the most threatened biomes due to anthropogenic and climate pressures, emphasizing the need to employ effective methodologies for assessing trends in aquatic biodiversity and habitat quality. Standardized, conventional methods for assessing fish, aquatic plants, and benthic invertebrates biodiversity are shifting to include new tools, such as environmental DNA (eDNA) and remote sensing techniques, to improve species detection and to increase overall sampling ability in remote locations. These methods have been incorporated into the Fish Identification Nearshore Survey (FINS) Project, a partnership between the River Institute (Cornwall, Ontario), Mohawk Council of Akwesasne, and Queen's University, to improve species detection and to address the undesirable impacts from conventional survey methods (e.g. fish mortality or habitat destruction) for assessing St. Lawrence River nearshore ecosystems. We compare the preliminary results of these emerging technologies with results from conventional survey methodologies used concurrently at each sampling location and discuss the benefits and limitations of each technique in large river systems. Furthermore, we discuss the importance and possibility of Indigenous Partnership for collective capacity building and meaningful engagement with the Akwesasronon biocultural context.

**Mason Marchildon**, Richard Gerber, Steve Holysh, Michael Doughty, Britt Smith and Steve Shikaze, Oak Ridges Moraine Groundwater Program, Toronto, ON, Canada. **Estimation of direct groundwater discharge and salt loading to the north shore of Lake Ontario.**

The role of groundwater on the Great Lakes is investigated along Lake Ontario's north shore. Streamflow captures most of the groundwater that contributes to Lake Ontario. Hydrograph separation performed on stream gauge data suggests that most of the measured stream flow (~2/3) in south-central Ontario streams originates from groundwater seepage, while overland runoff contributes the remaining third. Taking the lake's perspective, this two-thirds is here referred to as "indirect" groundwater discharge. In contrast, "direct" groundwater discharge along the Lake Ontario shoreline remains considerably uncertain. Here, 12 existing numerical 3D groundwater flow models are used to isolate direct and indirect groundwater discharge. Direct groundwater discharge to the north shore of Lake Ontario amounts to roughly 1/10th of total groundwater discharge, consistent with historical estimates. Combining the knowledge of long-term direct and indirect groundwater discharge to Lake Ontario's north shore along with groundwater chemistry, we estimate current chloride loadings from groundwater along the north shore by capitalizing on the existing groundwater data and knowledge assembled and managed by the Oak Ridges Moraine Groundwater Program. Current evidence suggests long-term direct (indirect) groundwater discharge loadings range from 2-14 (10-50) kta of chloride to the north shore of Lake Ontario. For context, total chloride loadings to Lake Ontario excluding inflow from Lake Erie are estimated to range from 1700-2500 kta (Chapra et al., 2009).

**Noribeth Mariscal**[1], Yaoxian Huang[1], Louisa K Emmons[2], Duseong S Jo[2], Ying Xiong[1] and Jiajue Chai[3,4], [1]Wayne State University, Detroit, MI, USA, [2]National Center for Atmospheric Research, Boulder, CO, USA, [3]State University of New York, Syracuse, NY, USA, [4]Brown University, Providence, RI, USA. **Evaluation of Ozone Using High-Resolution Model Simulations during the Michigan-Ontario Ozone Source Experiment.**

Exposure to excess ozone ($O_3$) levels can be detrimental to human health and agroecosystems. Southeast Michigan (SEMI) has been consistently classified as a nonattainment area for $O_3$ based on the National Ambient Air Quality Standards. Varied emission sources (i.e., point and mobile) and complex meteorology (i.e., temperature, relative humidity, winds, solar radiation, land-lake interactions) are likely

associated with these $O_3$ exceedances. However, it remains unclear what physical and chemical processes are leading to $O_3$ nonattainment, which is partially attributable to the lack of high-resolution, in-situ observations in SEMI. In this study, we explore the distributions of $O_3$ and its precursors (e.g., NOx and VOCs) over SEMI using a 3-D chemistry-climate model, MUSICAv0 (Multi-Scale Infrastructure for Chemistry and Aerosols, Version 0), constrained by the Michigan-Ontario Ozone Source Experiment (MOOSE) field campaign measurements in the summer of 2021. The current horizontal resolution of MUSICAv0 is ~14 km over the contiguous United States and ~111 km over the rest of the globe. To better understand the local scale impacts of chemical complexity existing in SEMI, we refined a domain over Michigan with a horizontal resolution of approximately ~7 km over Michigan. We then evaluated the MUSICAv0 model simulations at various resolutions (~14 km and ~7 km) against in-situ and airborne measurements of $O_3$ and its precursors during the MOOSE field campaign. The results of this study will allow us to quantify the drivers of $O_3$ nonattainment in SEMI.

**Christopher C Marshall**[1], Joseph K Connolly[1], Warren J.S. Currie[2], Kelly L Bowen[2], James M Watkins[1] and Lars G. Rudstam[1], [1]Cornell Biological Field Station, Bridgeport, NY, USA, [2]Fisheries and Oceans Canada, Burlington, ON, Canada. **Seasonal Zooplankton Community Trends: Lake Ontario CSMI 2018.**

The Lake Ontario zooplankton community has changed over the last three decades, including declines in cyclopoid copepods and increases in calanoid copepods, attributed to decreased offshore nutrient concentrations, increases in invasive predatory cladocerans, and changes in fish populations. However, our understanding of these offshore changes are primarily based on sampling in April and August, time periods that may not best represent annual changes in the lake. We present data on Lake Ontario's zooplankton community seasonal development utilizing samples collected during the bi-national inter-agency effort known as the 2018 Cooperative Science and Monitoring Initiative. The seasonal succession of the zooplankton community included an early and late spring dominated by cyclopoids, mostly *Diacyclops thomasii*, in both abundance and biomass, followed by calanoids in early spring, and calanoids (including *Limnocalanus macrurus*) in late spring. Both bosminids and daphnids increased in early summer, and there was a larger cladoceran contribution by the summer season, with maintained high cyclopoid densities. The community reached peak density (7000/$m^3$) and biomass (32 mg/$m^3$) in late summer, again dominated numerically by cyclopoids and only second to *Limnocalanus* in terms of biomass**.** The early and late fall communities had similar compositions to the summer sampling periods, with comparable overall abundance and biomass values. These 2018 data were compared to the long-term zooplankton time series to assess the status of the community over time.

**Sherry L Martin**[1], Martha Nielsen[2] and Timothy Cowdery[3], [1]US Geological Survey, Lansing, MI, USA, [2]USGS - Upper Midwest Water Science Center, Madison, WI, USA, [3]USGS - Upper Midwest Water Science Center, Mounds View, MN, USA. **A risk-based analysis of groundwater impacts on the water quality in Lake Superior.**

Groundwater is a major reservoir of fresh water in the Great Lakes Basin, serves as a conduit of non-point source contaminants, and has been under-studied until recently. As part of the 2021 Great Lakes Cooperative Science and Monitoring Initiative, a study was undertaken to characterize the groundwater of the Lake Superior basin. Of all the Great Lakes, the hydrology of Lake Superior is arguably the least well understood and relatively little is known about the quality and quantity of groundwater discharging to the Lake. Here we present a risk-based evaluation of potential contaminant fluxes to Lake Superior through groundwater pathways, with a focus on chloride and nitrate. We offer an expanded and unified characterization of the aquifers surrounding the US portion of Lake Superior, using published and measured values of aquifer properties. By taking a multi-metric approach, we evaluate the risk of direct and indirect groundwater discharge contributing to water quality concerns in Lake Superior. Risk factors include groundwater recharge rates, aquifer properties, distance to the shoreline, surficial and bedrock geology types, wetlands coverage, and soil organic carbon. We use decision tree analysis of measured groundwater chloride

and nitrate concentrations to calibrate weights for each risk factor and present the areal distribution of nitrate and chloride risk to the lake.

**Troy Martin** and Shelley Arnott, Biology, Queen's University, Kingston, ON, Canada. **Evaluating "eco-friendly" road de-icer effects on aquatic communities.**

Increasing use of road salt on North American roads and surfaces is contributing to rising salinity in freshwater, threatening aquatic ecosystems. In response to this, novel road de-icers advertised as "eco-friendly" have been developed. Despite rising popularity and use of road salt alternatives, research into their toxicities rarely extends beyond individuals, and community and ecosystem-level testing remains limited. We used outdoor mesocosms to test how zooplankton communities, important primary consumers in aquatic systems, responded to three common de-icers: rock salt (NaCl), an organic alternative (beet-juice/NaCl-brine blend), and an inorganic alternative (NaCl, $CaCl_2$, $MgCl_2$ blend). Each de-icer was tested along a gradient of 20 chloride concentrations ranging from ~6 to ~1500 mg/L. We found that both de-icer alternatives were more toxic to zooplankton and decreased total abundance greater than rock salt. However, the mechanisms of toxicity among de-icers may have differed; a decline in oxygen in the organic alternative correlated with the decline in zooplankton abundance. Within each treatment, cladocerans and copepods were far more sensitive than rotifers, indicating that taxa might be affected differently which could impact community composition and ecosystem function. These preliminary results could suggest that novel de-icer alternatives might not be as "eco-friendly" as advertised and we suggest that further testing is necessary, especially when considering broader effects such as trophic interactions.

**Frank Onderi Masese**[1], Elizabeth Wanderi[2,3] and Achieng Alfred Otieno[1], [1]University of Eldoret, Eldoret, Kenya, [2]Department of Fisheries and Aquatic Science, University of Eldoret, Eldoret, Kenya, [3]Kenya Fisheries Service, Lodwar, Kenya. **Challenges and strategies for management and conservation of the Lake Victoria Basin, East Africa.**

Worldwide, freshwater ecosystems have witnessed the most significant transformation, leading to dramatic reductions of their biodiversity, natural multi-functionality and the multiple ecosystem goods and services they provide. For the African Great Lakes regions, the greatest challenge is reconciling the needs of the rapidly growing human population with the ecological requirements of healthy and resilient ecosystems. We explore the challenges facing the Lake Victoria basin (LVB) and suggest management options and strategies for mitigating the continuous degradation of the lake and its basin. The Lake Victoria Basin (LVB) is endowed with natural resources that support livelihoods of over 40 million people. However, the unsustainable exploitation of these resources has led to various environmental challenges. These include land use change, degradation of wetlands, changes in water quality and quantity, proliferation of exotic species, declining fisheries and loss of biodiversity. Increasing conflicts over resource access and use and inadequacies in policy, laws and institutional structures further catalyze these challenges. To reverse the negative trends, management efforts should enhance participatory approaches through co-management, and improving the collation and dissemination of research findings. In addition, mainstreaming climate change in conservation and agricultural activities, development of monitoring protocols and novel approaches to sustaining conservation efforts should be enhanced.

**Catherine Masson**, Trent University, Peterborough, ON, Canada. **The COP-15 Kunming–Montreal Global Biodiversity Framework through a Freshwater Science–Policy Lens.**

The United Nations Convention on Biological Diversity (1992) is the legal instrument for the conservation of biological diversity, sustainable use, and fair and equitable sharing of genetic resources. In December 2022, the Parties to the Convention concluded the Kunming–Montreal Global Biodiversity Framework, resolving urgent action towards the 2050 Vision for Biodiversity, 'Living in Harmony with Nature.' The 2030 framework mission targets conservation of thirty percent of terrestrial, inland water and

marine and coastal ecosystems having high ecological integrity across regionally representative, equitable interconnected networks. These involve Indigenous protected and conserved areas (IPCAs), and other effective conservation measures (OECMs) on lands and waters maintained by Indigenous peoples and local communities. Targets contain cooperative provisions for nature-based solutions (NbS) concerning climate resilience and no net loss of ecosystem values, reducing extinctions and increasing species abundance by 2030. National commitments under the companion monitoring framework prescribe effective mechanisms for planning, monitoring, reporting and review, requiring governmental and institutional investments in enabling environments integrating scientific evidence with priority policy guidelines to support conservation management. The Kunming–Montreal Global Biodiversity Framework is an opportunity to discover, recover and share knowledge pertaining to the loss of biodiversity and ecosystem services in a changing climate.

**Hannah May**[1], Jana Levison[1], Andrew Binns[1], Sarah Rixon[1] and Pradeep Goel[2], [1]University of Guelph, Guelph, ON, Canada, [2]Ontario Ministry of the Environment, Conservation and Parks, Etobicoke, ON, Canada. **Nutrient dynamics in groundwater and surface water of an agricultural clay hydrosystem.**

Surface water quality in agricultural watersheds represents a combination of contributing water sources (e.g. groundwater flow, surface runoff, subsurface tile discharge) reflecting hydrogeologic character and land management. The role of groundwater in influencing nutrient concerns in streams is not well understood at the watershed scale. A 14-month field campaign was completed in a clay dominated watershed located in the Lake Huron Basin to assess nutrient quality throughout multiple components of the hydrologic cycle and in the context of antecedent and current weather conditions. Phosphorus in groundwater were typically low but demonstrated catchment wide peaks in dissolved reactive phosphorus under certain climate conditions. Tile drains were expected to mobilize nutrients from the subsurface to surface waters, modifying hydrologic connections and affecting the potential for groundwater-surface water interaction in agricultural settings. Water quality of the hyporheic zone was influenced by both surface water and groundwater under varying spatiotemporal scales and in relation to weather events. Contributions of groundwater to surface water nutrient quality in this setting may be limited by hydrogeology, although groundwater was found to have temporally variable levels of nutrients and be impacted by seasonal weather events.

**Greg Mayne**, Environment and Climate Change Canada, Burlington, ON, Canada. **Assessing and Enhancing the Resilience of Great Lakes Coastal Wetlands.**

In the face of climate change, the resilience of Great Lakes coastal wetlands is paramount. These vital ecosystems provide valuable services and safeguard biodiversity, yet they continue to be threatened by land-based stressors and the compounding effects of a warming planet. Environment and Climate Change Canada has completed a novel assessment of coastal wetland resilience to climate-related risks and impacts. The study found that climate models predict future warmer and wetter conditions for the Great Lakes region, with increased variability and extremes in lake levels. Wetlands study sites varied in their adaptive capacity based on factors such as agriculture and urbanization, invasive plant density, migration potential, and land protection. Area-based wetland ecological attributes, such as meadow marsh and total wetland area, were most sensitive to high lake level simulations. The study determined that coastal wetlands in eastern Lake St. Clair, the Detroit River, and western Lakes Erie and Ontario are most vulnerable to simulations of future climate change. A suite of priority adaptation strategies and measures are provided to the Great Lakes conservation community to take action, protect, and enhance the resilience of these vital coastal ecosystems.

**Bhaswati Mazumder**, Claire Oswald and Christopher Wellen, Toronto Metropolitan University, Toronto, ON, Canada. **Salt to stream: A process-based integrated watershed model for urban stream chloride from winter salts using SWMM.**

Freshwater salinization from winter salts has led chloride (Cl) to be one of the most common water quality threats in North America. Currently there is a need for models that integrate long-term, continuous hydrological processes with water quality, for investigating how mesoscale watersheds respond to land use and climate change. The use of such models in urban planning is often deterred by limitations in data, time, and software expertise. In this study, we created a watershed model for Etobicoke Creek, a heavily urbanized watershed flowing into Lake Ontario, with the widely used Storm Water Management Model (SWMM). Using openly available data from daily streamflow and monthly Cl observations, we calibrated the model with land use and climate conditions in 2018-2020, then validated using those in 2011-2013. Using Kling-Gupta Efficiency (KGE), Nash-Sutcliffe Efficiency (NSE), coefficient of determination ($R^2$), and percent bias (PBIAS), we found that model performance was optimized at the scale of monthly averages. Comparison with high-frequency (15-minute) water quality data from 2021 showed that the timing and magnitude of winter peaks were misrepresented, while Cl at low-concentration periods (e.g. summer months) were simulated adequately (monthly NSE up to 0.6). We also compared the model's ability to capture exceedances over chronic (120 mg/L) and acute (640 mg/L) Canadian Water Quality Guidelines for freshwater organisms. The model captured chronic exceedances within 3% of observations, but failed to represent acute winter exceedances.

**Kelly McCabe**[1], Ashley Burtner[1], Jasmine Mancuso[1], Glenn Carter[1], Christine Kitchens[1], Andrew Camilleri[1], Anna Boegehold[1], Reagan M. Errera[2] and Casey M Godwin[1], [1]Cooperative Institute for Great Lakes Research, University of Michigan, Ann Arbor, MI, USA, [2]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, USA. **Phosphorus Forms in the Western Lake Erie Basin Before, During, and After HAB Conditions.**

Management efforts to mitigate the Western Lake Erie basin (WLEB) harmful algal bloom (HAB) have focused on reducing phosphorus (P), especially total P (TP), loads to the basin. Those TP loads are a mix of particulate and dissolved, inorganic and organic forms that are not equally bioavailable to phytoplankton. Research has documented an increase in the fraction of bioavailable P, specifically soluble reactive P (SRP), entering the lake through the Maumee River, however less is known about the *in situ* composition of P after it enters the lake, how the composition varies over time and space, and how this compositional variability interacts with WLEB HAB dynamics. To better characterize the WLEB P composition and its relationship to the HAB, we leveraged our HABs monitoring program to collect samples for measurement of nine compositional forms of P from 8 set stations and along 6 transects within the WLEB during the spring, summer, and fall of 2021. This dataset tracks the compositional changes in P before, during, and after the annual HAB as well as the compositional differences in P from two riverine sources (i.e., Maumee River and Detroit River) and the transformation of these P inputs as the P cycles through the basin.

**Francine McCarthy**[1], Erin Ghosh[1], Joshua Moraal[1], Autumn Heyde[2] and Paul Hamilton[3], [1]Brock University, St. Catharines, ON, Canada, [2]Brock University, St. Catharines, Canada, [3]Canadian Museum of Nature, Ottawa, ON, Canada. **The wealth of non-pollen evidence of environmental change in 'pollen slides': applications to decision-making.**

Dissolving minerals from sediment samples leaves behind many particules in addition to pollen and plant spores. These include the organic-walled remains of algae (including previously undocumented loricae of the chrysophyte *Dinobryon divergens*) and their consumers (micro-invertebrates such as rotifers and cladocerans, and a variety of protozoans) as well as chemically inert particles like fly ash and microscopic charcoal. These provide insights into natural and anthropogenic change in the North American Great Lakes basin since deglaciation and can be used to refine models upon which decisions will be made. It is particularly important to identify the fundamental shift in Earth systems that accompanied the Great Acceleration of in the mid-20$^{th}$ century that is being proposed to define the proposed Anthropocene epoch. These shifts are inherently related to local, regional and global stressors. In the Great Lakes basin one metric

of note, the decline in elm pollen reflecting Dutch elm disease, will be a useful marker for the proposed boundary between the Holocene and Anthropocene epochs.

Marie G Bezold[1], Silvia E Newell[1], Christopher K Gomez[1], Joseph L Davidson[1,2], Justin A Myers[1], Shannon M Collins[1], Steve Fondriest[2] and **Mark J McCarthy**[3], [1]Wright State University, Dayton, OH, USA, [2]Fondriest Environmental, Inc., Fairborn, OH, USA, [3]Estonian University of Life Sciences, Tartu, Estonia.
**The role of an agricultural settling pond as a source vs. sink for nitrogen runoff.**

Excess loading of nitrogen (N) and phosphorus (P) causes eutrophication, a global problem with negative impacts on water quality in aquatic systems, including harmful algal blooms and bottom-water hypoxia. Anthropogenic activities (e.g., Haber-Bosch process, burning of fossil fuels, sewage treatment, and manure usage as fertilizer) have led to excess N loading to aquatic systems. Constructed wetlands and settling ponds in agricultural landscapes are one of many approaches used to minimize nutrient pollution reaching surface waters. Sediment N dynamics were examined from Sept 2019-Oct 2020 in a settling pond connected to a constructed wetland adjacent to an agricultural field. Intact sediment cores were amended with $^{15}N$ for continuous-flow incubations to measure denitrification and N fixation rates, as well as net nutrient and oxygen fluxes. Net $N_2$ consumption (N fixation > denitrification) was observed over most of the year, suggesting that pond sediments were usually a net N source. Denitrification was stimulated when $^{15}N$-nitrate was added, and net denitrification was observed following a N fertilizer application in May 2020. NOx entering the settling pond was rapidly transformed or assimilated. However, during winter and following fertilizer application, ambient NOx concentrations increased in the wetland, but remained lower in the settling pond, suggesting that denitrification in the pond acted as a valuable ecosystem service. Settling ponds in agricultural settings thus have the potential to supplement agricultural nutrient control practices.

**Daryl McGoldrick** and Allison Puhl, Environment and Climate Change Canada, Burlington, ON, Canada.
**Environment and Climate Change Canada, open science, and Great Lakes water quality monitoring datasets.**

In 2020, the Government of Canada (GOC) launched the Roadmap for Open Science that sets out principles and recommendations intended for science and research funded by GOC departments and agencies. Two important themes in these recommendations are that our science products should be "Open by design and by Default" and information on open portals is "Findable, Accessible, Interoperable, and Reusable" (FAIR). The Water Quality Monitoring and Surveillance Division (WQMSD) of Environment and Climate Change Canada, has embraced these principles and at present maintains >70 open datasets on the GOC open data portal including 9 for the Great Lakes basin. These datasets contain data from our monitoring in water, sediments, and aquatic biota for physical characteristics, nutrients, metals, organic contaminants, and/or algal biomass. Our service standard mandates that, where possible, these records be updated every 30 days so that they contain the latest information and corrections to errors are reflected quickly. WQMSD have also linked their relevant datasets with the Great Lakes DataStream, a platform that increased their findability and accessibility to users. Moving forward, WQMSD is currently implementing a new data management system that should enable the development of web portals, improve accessibility, and reduce time lags for data uploaded to the open portal.

**Robert Michael McKay**[1], Elizabeth R. Denison[2], Brittany N. Zepernick[2], Thijs Frenken[1,3], George S. Bullerjahn[4] and Steven W. Wilhelm[2], [1]Great Lakes Institute for Environmental Research, University of Windsor, Windsor, ON, Canada, [2]University of Tennessee, Knoxville, TN, USA, [3]Cluster Nature & Society, HAS University of Applied Sciences, s-Hertogenbosch, Netherlands, [4]Bowling Green State University, Bowling Green, OH, USA.
**Metatranscriptomic analysis of winter planktonic communities from Lake Erie spanning climatic gradients.**

While great effort has been made to resolve biomass generation and species composition in summer algal blooms that continue to plague the Laurentian Great Lakes, recent interest has turned to winter production, including ice-associated diatom blooms that occur in Lake Erie. These blooms can generate biomass that rivals summer blooms and likely drive recurrent central basin hypoxia in the lake. Providing a glimpse into winter phytoplankton composition and function, samples were collected and processed for metatranscriptomic analyses across 77 stations via opportunistic sampling by Canadian and U.S. Coast Guard assets from 2019-2021. Samples spanned spatial, temporal and climatic gradients including a near ice-free winter in 2020. RNA sequencing of the samples has so far revealed new insight into how diatoms as well as other bioactive components of the system (eg. viruses) change across seasons and in the presence or absence of ice cover. But this effort also serves as a cautionary tale highlighting how different sampling approaches can lead to variations in observation that may not be attributable to in situ environmental conditions. This study demonstrates the need for precise protocols to be documented and for variability in sampling approaches to be considered in the analyses and intercomparison of data collected across large temporal and spatial scales.

**Rachel McNamee**[1], Emilie Montreuil Strub[1], Desiree Langenfeld[2], Rebecca Rooney[3], Timothy Hoellein[4], Chelsea Rochman[5] and Diane Orihel[6], [1]University of Waterloo, Waterloo, ON, Canada, [2]University of Manitoba, Winnipeg, MB, Canada, [3]Biology, University of Waterloo, Waterloo, ON, Canada, [4]Loyola University Chicago, Chicago, IL, USA, [5]University of Toronto, Toronto, ON, Canada, [6]Queens University, Kingston, ON, Canada. **Microplastics increase primary production and respiration in pelagic mesocosms.**

Primary production and respiration are essential processes influenced by lake microbial communities. Yet, the effects of microplastics on primary production and respiration is not well studied. We set up 9 mesocosms (10 m wide, 2 m deep) in the pelagic zone of a lake in Northwestern Ontario. We added microplastics (equal parts of 3 polymer types) to seven of the mesocosms (concentration range = 0 – 29,240 particles/L), with two control mesocosms. We measured the effects of microplastics on biofilm metabolism via change in dissolved oxygen in paired light and dark bottles. We calculated respiration, net primary production, and gross primary production rates. We also quantified metabolism on the polyethylene mesocosm wall material using a piece incubated in the mesocosms for this purpose. Respiration and net primary production rates increased with microplastic concentrations ($p = 0.04$ and $p < 0.01$, respectively), with no impact on gross primary production ($p = 0.93$). The addition of mesocosm wall material had no effect on net primary production ($p = 0.58$), respiration ($p = 0.25$), or gross primary production ($p = 0.76$). These findings provide evidence for a fertilization effect of microplastics on primary producers. Further research is needed in the natural littoral communities.

**Kelsey McNeill**, Credit Valley Conservation, Mississauga, ON, Canada. **Tracking ecological impacts of climate change: A process for selecting valuable climate change indicators.**

With continued changes anticipated for Ontario's climate, there is a need to track the impact of climate change on the natural environment. This knowledge can be used to develop and prioritize adaptation measures to lessen the impact of these changes. Credit Valley Conservation's Integrated Watershed Monitoring Program undertook a process to select a suite of indicators to help track the impacts of climate change to the watershed's ecosystems. This rigorous four-step process involved identifying candidate indicators, developing a scoring system, scoring indicators, and the selection of final indicators. This flexible approach can be adopted by other organizations to aid in selecting climate change indicators that fit within their goals and resources. In this presentation, I will share details of the approach taken, how it can be applied by others, our final suite of selected indicators and next steps for integrating it into our long-term watershed monitoring program.

**Laura McNeill** and Catherine Eimers, Trent University, Peterborough, ON, Canada. **Effects of tile drainage, seasonality and cash crop rotation on edge-of-field nutrient losses in southern Ontario.**

The eutrophication of water bodies is an ongoing global problem and agriculture is an important non-point source of nutrient loading. In southern Ontario, agriculture has intensified in recent decades, with major expansions of cash crop production and extensive tile drainage (TD). Through intensive monitoring of 13 tile outlets draining operational fields under the conventional corn-soybean-winter wheat rotation (with winter cover crops including winter wheat and mixed cover crop species), this study examined differences in nitrogen (N) and phosphorus (P) losses seasonally over a two-year period. The majority of nutrient export occurred during the non-growing season (NGS) (October - April) in both study years and fields with winter cover crops did not have lower nutrient losses. Instead, the highest nitrate-N losses occurred under winter wheat in both NGSs. There was no clear relationship between N losses and crop cover during either growing season (GS) and tile discharge was also substantially lower. As for P, export was highly sensitive to flow events, including rain-on-snow and spring melt, and like N, there was no relationship between winter crop cover and P export. The results of this study may help inform agricultural management by addressing the urgent need for improved information around the relationship between agricultural practices and nutrient losses especially in the non growing season.

**Amelia McReynolds**[1], Bernie Pientka[2], J. Michael Jech[3], Lars G. Rudstam[4], J. Ellen Marsden[1] and Jason Stockwell[1], [1]University of Vermont, Burlington, VT, USA, [2]Vermont Fish and Wildlife Department, Essex Junction, VT, USA, [3]Northeast Fisheries Science Center (NOAA), Woods Hole, MA, USA, [4]Cornell Biological Field Station, Bridgeport, NY, USA. **Mechanisms of coexistence between native rainbow smelt and invasive alewife in Lake Champlain.**

Mid-trophic level fishes are critical links in pelagic food webs that can be impacted by ecosystem change, predation, and species invasions. These factors may interact in complex, unpredictable ways to cause dramatic swings in biomass or changes in species composition of pelagic fish communities. From 1990 to 2015, hydroacoustic and net surveys of small pelagic fishes were conducted in Lake Champlain, a large, fragmented lake comparable to the Laurentian Great Lakes. This survey encompassed a period before and during alewife (*Alosa pseudoharengus*) invasion into a pelagic fish community dominated by native rainbow smelt (*Osmerus mordax*). Following the invasion, rainbow smelt rapidly declined in some regions of the lake. We analyzed 11 years of survey data from three ecologically distinct basins in Lake Champlain to examine interactions between rainbow smelt and alewife. We quantified effects of alewife invasion on rainbow smelt by comparing spatial distributions, oxythermal habitat use, and biomass and abundance estimates between the two species. Trends at large and small scales revealed differing patterns of species' coexistence among basins. Our results provide spatially explicit insights into interactions between rainbow smelt and alewife across gradients of lake bathymetry, oxythermal habitat availability, and prey composition.

**Abigail Melendez**, Amanda Welsbacher, Hannah Phillips, Ivor Knight and Matthew Gruwell, Penn State Behrend, Erie, PA, USA. **Collection, Identification, and qPCR Analysis of Aquatic Invasive Amphipods in The Great Lakes.**

Class Malacostraca is a diverse group of over 25,000 species and includes the major Crustacean groups of lobsters (Decapoda), woodlice (Isopoda), mysids (Mysida) and side swimmers (Amphipoda). Within any group of organisms, some play valuable roles, and some act as AIS in their environment. AIS are non-native in their environment and their presence potentially causes economic/ecological harm. To better understand the distribution of invasive species in the Great lakes, species presence can be detected with eDNA in filtered water, once discriminating oligonucleotide probes have been developed. In Lake Erie, we have targeted three species of Amphipods for investigation; Echinogammarus ischnus, Gammarus fasicatus, and Gammarus tigrinus. When sampling around Presque Isle, an overwhelming percentage of species were found to be E. ischnus, while the others were rare or non-existent. Due to the prevalence of E. ischnus, they are of most interest in probe development. G. fasciatus is still important because of its classification as a

non-native species, that has also been collected locally. No matter the amount collected, developing primers for each species is required because of their close phylogenetic relationships. Natural history research, collection, and probe creation information was collected for these target scuds over the summer and fall of 2022. This record and data will aid in the detection of these species throughout the Great Lakes.

**Zach Melnick** and Yvonne Drebert, Inspired Planet Productions, Miller Lake, ON, Canada. **Swimming with the Fishes: Using Underwater Drones (ROVs) to Observe Fish Behaviour.**

Our terrestrial nature creates obvious barriers to observing the behaviour of aquatic species. While both scuba and drop cameras allow us to temporarily subvert some of these constraints, strict time, depth, temperature, safety, and other limitations prevent us from truly "swimming with the fishes." Remotely-operated-vehicles (ROVs) have the capacity to both explore previously unreachable underwater environments and observe animal behaviours in ways never before possible, with the added benefit of incurring zero animal mortalities. Recent advances in ROV and low-light camera technology allow us to "swim" further, deeper, and longer than with older models, while viewing 4k results in real time from the surface. After more than 20 years creating documentary film, our team has taken a deep dive into the world of ROVs as tools for both filmmaking and research. We've been ROVing in both degraded and thriving environments throughout the Great Lakes, from the nearshore to the most extreme depths. We're excited to share our successes and the challenges we've encountered, as well as our learnings around techniques, gear, post-processing, and other tools to optimize our chances of capturing animal behaviours. We see our work as straddling the line between art and science. Our goals are: 1) to bring freshwater species and ecosystems into the spotlight usually reserved for marine/ocean environments, and 2) to capture footage that will help our scientific partners expand their understanding of species that need our help now more than ever.

**Richard Melstrom**[1] and Jillian Hyink[2], [1]Loyola University Chicago, Chicago, IL, USA, [2]University of Arkansas, Fayetteville, AR, USA. **Do water quality improvements in Areas of Concern affect moves to nearby communities? Evidence from Michigan.**

This presentation will feature research examining whether water quality improvements around the Great Lakes affect moves to coastal communities. Spread around the Great Lakes are a number of Areas of Concern (AOCs) with high levels of persistent toxic substances that the United States and Canada have identified as priorities for restoration. Prior research finds a relatively weak association between coastal amenities and residential mobility in the region. Our research takes a closer look at the effects of water quality on mobility. While prior research has examined residential demand near AOCs, this research largely infers the effects of cleanup based on distance to pollution as a residential location characteristic, rather than actual water quality improvements as we do here. Our evidence comes from a sorting model that uses a unique combination of geographically-aggregated choices, location characteristics, and local water quality restoration actions. Unlike traditional statistical models of homes sales and prices, sorting models can account for moving costs and recover household economic values in the presence of heterogeneous preferences. Relying on aggregated rather than individual mobility data, as we do here, also allows us to model location decisions over two decades, before and after several water quality improvements in a large number of AOCs, which should increase confidence in our estimates of the effect of water quality on moves to coastal communities.

**Greg Melvin**[1], Carrie Sadowski[2], Janet Greenhorn[2] and Jeff Bowman[2], [1]Trent University, Peterborough, ON, Canada, [2]Ontario Ministry of Natural Resources and Forestry, Peterborough, ON, Canada. **Muskrat Population Density Not Correlated with Invasive Hybrid Cattail in Southern Ontario.**

Muskrat (*Ondatra zibethicus*) populations are declining in North America. In the Great Lakes, decades of stabilized water levels have allowed cattails (*Typha* spp.) to dominate coastal marshes, particularly the invasive hybrid *T. x glauca*. This hybrid forms dense monocultures and reduces wetland interspersion which

may be detrimental to muskrat habitat. We hypothesized that muskrat declines are linked to the invasion of *T. x glauca*. Our study included 39 cattail-dominated marshes in southern Ontario. We sampled cattail communities across sites and conducted muskrat house counts to estimate population density. We also measured interspersion as water edge-length per unit area using ArcGIS. We predicted that muskrat densities would be negatively correlated with relative abundance of *T. x glauca* and positively correlated with interspersion. We found no correlation between house densities and *T. x glauca* across sites; however, most sites were dominated by *T. x glauca*. Interspersion was a good predictor of house densities, but there was no significant correlation between *T. x glauca* and interspersion. These findings confirm that interspersion plays an important role in supporting muskrats, but the ubiquity of *T. x glauca* in this region has made it difficult to uncover a link between widespread muskrat declines and this aquatic invader.

**Justin Meyer**[1], David G Fielder[2], Tomas O Hook[1,3] and Paris D Collingsworth[1,3], [1]Purdue University, West Lafayette, IN, USA, [2]Michigan DNR, Alpena Fisheries Research Station, Alpena, MI, USA, [3]Illinois-Indiana Sea Grant, West Lafayette, IN, USA. **Hypoxia in Saginaw Bay: Assessing its prevalence and trophic effects on a benthic invertebrate.**

Hypoxia, or low dissolved oxygen, is an important factor to consider in evaluating water quality of aquatic systems. Hypoxia has received heightened attention in recent years due to increasing incidences and severity of hypoxic conditions in the Great Lakes and bottom hypoxia is listed as a major concern for ecosystem health in the Great Lakes Water Quality Agreement. We used Precision Measurement Engineering miniDOT data loggers to continuously record bottom water dissolved oxygen conditions in Saginaw Bay at point stations over three seasons and incorporated an existing geostatistical interpolation framework to assess bay-wide occurrences of hypoxia. Results indicated periods of hypoxia occurred in the summers of 2021 and 2022, while normoxic conditions were maintained bay-wide throughout the intervening overwinter period. Additionally, we measured carbon-13, nitrogen-15, oxygen-18 and hydrogen-2 stable isotopes of chironomid midges along a productivity gradient across Saginaw Bay to assess the effects of hypoxia on an important food source. Results will indicate if variation in trophic reliance is consistent with productivity gradients and spatial and temporal patterns of low oxygen for the hypoxia-tolerant insects. This study highlights the utility of fine-scale monitoring in capturing spatiotemporally dynamic conditions like hypoxia and offers insight into hypoxia's influence on the bay's basal food web.

**Andrew D. Miller**[1], Karen Alofs[1] and Bradley J. Cardinale[2], [1]University of Michigan, School for Environment and Sustainability, Ann Arbor, MI, USA, [2]Pennsylvania State University, Department of Ecosystem Science and Management, State College, PA, USA. **Modeling habitat influences on the distribution of native Great Lakes fishes to inform management and restoration.**

Coastal ecosystems are hotspots of biological productivity and key habitats for many Great Lakes fish species. Historical anthropogenic disturbance of these ecosystems has necessitated substantial investment in habitat restoration activities. Effective planning and evaluation of restoration projects benefit from the use of spatial benchmarks, which may be based on modeled species distributions and habitat associations. We combined fish occurrence records from several regional datasets with georeferenced habitat variables to develop distribution models and identify important habitat relationships for a group of native Great Lakes fish species in Lakes Erie, Michigan, and Superior and the Huron-Erie Corridor. We use these relationships to predict the potential outcomes of various habitat restoration actions and highlight how these models can be used to develop spatial benchmarks for coastal habitat restoration efforts.

**Mary Ellen Miller**, Laura Bourgeau-Chavez, Dorthea Leisman Vander Bilt, Vanessa Barber and Michael Battaglia, Michigan Tech Research Institute, Ann Arbor, MI, USA. **Mapping wetland hydrological connectivity in the Laurentian Great Lakes.**

The coastal wetlands of the Great Lakes have experienced record high and record low water levels over the past decade. Given the need to protect coastal wetlands and their important contributions to the health of the lakes, it is crucial to understand how these wetlands respond to relatively rapid water level fluctuations, which are likely to affect both wetland extent and type. To support the informed management of coastal resources we have developed an algorithm to identify wetlands that are hydrologically connected to the Laurentian Great Lakes. Using both high resolution Smallsat commercial data and hydro-enforcement algorithms, we have mapped wetland connectivity at low, average, and high water levels within the Basin. Historical field observations and image interpretation are used to validate model results. Going forward we are incorporating our connectivity wetland maps and inundation period into wetland change studies in order to better understand the impacts of climate, anthropogenic expansion and changing water levels on wetland ecosystems.

**Todd R Miller**, Wilson Tarpey and Jeffrey Nuese, University of Wisconsin - Milwaukee, Milwaukee, WI, USA. **Panther Buoy: A Solar Powered Open Source Water Quality and Weather Monitoring System.**

We have built a low cost, open source solar powered data buoy system with a suite of sensors useful for monitoring weather and water quality conditions in the Great Lakes. We call this system the Panther Buoy. The data logger consists of a single printed circuit board programmed using open source C/C++ software (e.g. Arduino IDE) and contains an embedded cellular, bluetooth, LoRa and wireless modems, screw terminal inputs for a suite of weather and water quality sensors. Data communications use analog, I2C, RS232, and SDI12. The system is powered by a 19.9 amp-hour lithium-ion polymer battery pack charged using a custom made maximum power point tracking charge controller and three solar panels. We present data from two deployments in the Great Lakes with Turner Cyclops 7F chlorophyll and phycocyanin fluorometers, an ATMOS22 ultrasonic anemometer, an In Situ RDO Pro dissolved oxygen sensor, a Bosch BME680 temperature, pressure, and relative humidity sensor and a custom built temperature chain. Data was sent in near real time (every 5 minutes) to an SQL database and presented in interactive dashboards at our website lakestat.com. Results of these deployments suggest the system may be useful for expanding weather and water quality observations in the Great Lakes region and elsewhere.

**Michael Milligan**[1], Sujan Fernando[2], Bernard Crimmins[2], Thomas M. Holsen[2], Philip Hopke[2] and James J. Pagano[3], [1]SUNY Fredonia, Fredonia, NY, USA, [2]Clarkson University, Potsdam, NY, USA, [3]SUNY Oswego, Oswego, NY, USA. **Toxaphene Concentrations in Great Lakes Fish: 2004-2020.**

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 since 2004 for a suite of legacy and emerging contaminants of concern. Whole fish Lake Trout composites from all five Great Lakes have been extracted and analyzed using GC/ECD, GC/MS, GC/MS/MS, and GCxGC/TOF-MS to identify and quantify analytes such as PCBs, dioxins, organochlorine pesticides, flame retardants, and PFOS. In this work we will report on concentrations and temporal trends of toxaphene in top predatory Great Lakes fish over the past seventeen years. Toxaphene is a complex mixture of hundreds of chlorinated bornanes and camphenes that was used as a pesticide in the 1960s and 1970s, primarily on cotton crops in the southern United States. It is believed that atmospheric transport processes have led to deposition of toxaphene into the Great Lakes, and their subsequent bioaccumulation in the food web. Since 2004, we have measured toxaphene concentrations in Great Lakes fish to decrease by approximately a factor of three. Lake Trout samples collected in 2019 show the following concentrations, in order from highest to lowest: L. Superior = 115 ng/g, L. Michigan = 81 ng/g, L. Huron = 55 ng/g, L. Ontario = 47 ng/g, and L. Erie = 39 ng/g.

**Kristie Mitchell**[1], Lyndsie Collis[2], James M Hood[3], Henry A. Vanderploeg[4] and Subba Rao Chaganti[5], [1]University of Michigan, Ann Arbor, MI, USA, [2]The Ohio State University, Department of Evolution,

Ecology, and Organismal Biology, Columbus, OH, USA, [3]Aquatic Ecology Lab, The Ohio State University, Columbus, OH, USA, [4]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, USA, [5]Cooperative Institute for Great Lakes Research, University of Michigan, Ann Arbor, MI, USA.
**Metabarcoding for predicting the impact of invasive species on the microbial food web.**

The food web in the Laurentian Great Lakes has undergone dramatic changes over several decades. Specifically, these changes include altered nutrient concentrations, as a result of agricultural practices, collapse of invasive plankton-consuming alewives as a result of both salmon predation and competition with quagga and zebra mussels for food, and loss of the spring phytoplankton bloom due to filter feeding by dreissenids. Although the changes in the upper food web is visible, little is known about shifts in the different species within the microbial food web (MFW) and their direct impacts on the zooplankton grazing pattern and its indirect impact on fisheries. A key to understanding MFW dynamics is identifying predator (zooplankton)-prey relationships within the MFW, which involves depicting zooplankton feeding preferences. A combination of 16S rRNA and 18S rRNA universal gene target metabarcoding analysis can determine prey in the gut contents for both prokaryotes and eukaryotes. However, a major problem is that DNA extracted from the gut contents are heavily contaminated by predator DNA and 18S rRNA metabarcoding results in >99% of host sequences. We developed CRISPR-Cas-9 Selective Amplicon Sequencing (CCSAS) markers, which targets and cuts specially predator 18S rDNA, vastly increasing the proportion of prey DNA to predator DNA in the resulting sequencing library, thereby helping us determine the selective grazing patterns of variety of native and invasive zooplankton.

**Dejana Mitrovic**[1], Hugo Flávio[2], Leslie M Bragg[1], Mark Servos[1] and Michael P Wilkie[2], [1]University of Waterloo, Waterloo, ON, Canada, [2]Wilfrid Laurier University, Waterloo, ON, Canada. **Water Temperature Influences the Sensitivity of Larval Sea Lamprey (*Petromyzon marinus*) to Lampricides.**

Lampricide, TFM (3-trifluoromethyl-4'-nitrophenol) applications to larval sea lamprey infested tributaries have been highly successful at controlling parasitic sea lamprey populations in the Great Lakes. Compared to non-target fishes, larval sea lamprey are more sensitive to TFM because of their limited ability to detoxify and excrete the lampricide. This results in TFM accumulation within the tissues and impairs ATP production leading to energy depletion and eventual death. Environmental factors, pH and alkalinity, can significantly impair TFM effectiveness by reducing TFM bioavailability. Additionally, recent work suggests that water temperature may also influence TFM toxicity, which may explain why sea lamprey TFM tolerance increases in the summer. LC-MS/MS was used to measure TFM within the liver and muscle of lamprey acclimated to one of three temperatures (6,12 and 24°C) and exposed to 12°C 12-h $LC_{25}$. Lower TFM accumulation in the tissues of sea lamprey at warmer temperatures was observed, supporting our hypothesis that sea lamprey's ability to survive TFM treatments at warmer temperatures was due to an enhanced capacity to detoxify TFM. These findings suggest that in an ever-warming climate, higher sea lamprey tolerance to TFM will necessitate the use of more TFM for effective sea lamprey control, resulting in greater risks to non-target organisms in the Great Lakes' tributaries. Climate change adaptation strategies may include altering the timing and protocols of TFM applications or relying more on alternate strategies of sea lamprey control.

**Sheida Moin**[1], Steve Auger[2], David Lembcke[3] and Tim Krsul[4], [1]Lake Simcoe Region Conservation Authority, Bradford, ON, Canada, [2]2450 9th Line, Bradford, ON, Canada, [3]Lake Simcoe Region Conservation Authority, Newmarket, ON, Canada, [4]Ontario Ministry of the Environment, Conservation, and Parks, Newmarket, ON, Canada. **Inspection, Maintenance, and Resourcing Needs for Stormwater Features in the Lake Simcoe Watershed.**

In 2010, there were approximately 200 stormwater management (SWM) ponds identified in the Lake Simcoe watershed. Over the last decade this number has grown to over 500 ponds. Our initial research efforts assessed the number and status of these facilities and estimated the status of water quality treatment or impact to the receiving water. This study concluded that over half of the SWM ponds in the watershed

were not being maintained properly, resulting in these features acting as sources, not sinks for controlling urban stormwater pollution. Since 2014, LSRCA has consulted with municipal staff overseeing inspection and maintenance programs. Through these consultations, we have identified some key resource and information gaps Lake Simcoe watershed municipalities face, including inventory tracking, training, and financial resources to effectively perform the maintenance needed for the ponds. This presentation will feature how the Lake Simcoe watershed Municipal SWM database along with the prioritization methodology incorporated within, is supporting municipal SWM programs. The collaborative outreach to improve municipal SWM programs through the Lake Simcoe watershed LID inspection and maintenance working group for the watershed along with STEP-Water training throughout Ontario will also be highlighted.

**Hafsa Momin**[1], Jenn Drake[2] and Claire Oswald[3], [1]University of Toronto, Toronto, ON, Canada, [2]Carleton University, Ottawa, ON, Canada, [3]Toronto Metropolitain University, Toronto, ON, Canada. **Influence of Stormwater Management Ponds on Chloride Transport to Urban Headwater Streams.**

Sodium chloride (NaCl) is used as a de-icing agent in both solid and brine forms on paved surfaces. During rain and melt events, urban runoff transports the salt ions through pipes and sewer networks to stormwater management ponds. Previous studies have shown that due to densimetric stratification in the pond itself, discharging water can generate chloride ($Cl^-$) pulses to the receiving stream that exceed thresholds of acute toxicity to aquatic biota. This study aims to investigate the prevalence of this phenomenon in the headwaters of the Lake Ontario and Lake Simcoe basins. Five headwater streams receiving flow from wet stormwater ponds in the two basins and two streams with no stormwater treatment were instrumented with conductivity sensors in October 2021. In combination with discrete sampling for $Cl^-$ analysis, fifteen-minute conductivity data is collected from monitoring stations up- and downstream of each pond outlet to develop a continuous $Cl^-$ time series for the sites. Differences in $Cl^-$ concentrations between up and downstream stations are used to identify $Cl^-$ pulses associated with flushing of the stormwater ponds. Preliminary results indicate varied behaviour in ponds as only some generate pulses that exceed acute toxicity thresholds, while receiving streams consistently exceed chronic toxicity thresholds throughout the salting season.

**Brandon E. Monteiro**[1], Julian Aherne[1] and Paul Helm[2], [1]Trent University, Peterborough, ON, Canada, [2]Environmental Monitoring and Reporting Branch, Ontario Ministry of the Environment, Conservation and Parks, Toronto, ON, Canada. **Abundance and Characteristics of Microplastics in Urban Stormwater Ponds.**

It is estimated that millions of kilograms of plastics and microplastics (MPs) enter the Great Lakes every year. The primary pathways of MPs to the Great Lakes are through wastewater discharge, atmospheric dispersion, and direct urban runoff into streams. In urban areas, stormwater ponds (SWP), which are artificial water bodies, are designed to collect urban runoff from their surrounding area, mitigate floods, and retain pollutants. However, in the Greater Toronto Area, little is known about MP abundance in SWP and their capacity to retain and redirect MPs from entering Lake Ontario. To understand the role of SWP in the MP cycle, we examined surface water in SWPs (n=12) within the Etobicoke Creek Catchment, which extends from Caledon to Toronto and drains into Lake Ontario. Within the Etobicoke Creek Catchment, SWPs are associated with a variety of land use types, which may reflect distinct MP sources; as such we selected SWPs across three dominant land use types; industrial (n=5), residential (n=4) and commercial (n=3). The objective of this study is to better understand the abundance and characteristics of MPs in SWPs associated with different dominant land use types. This will inherently provide context on the sources of MP entering Lake Ontario.

**Danielle Sylvia Montocchio**[1] and Pat Chow-Fraser[2], [1]McMaster University, Hamilton, ON, Canada, [2]Biology, McMaster University, Hamilton, ON, Canada. **How the CSR strategies of macrophytes in coastal wetlands influences their responses to water levels.**

Since Grime developed his "Competition-Stress-Ruderal" (CSR) triangle to predict terrestrial plant distributions in Britain along resource gradients, the theory has been applied globally to other terrestrial systems and recently to aquatic systems. Here, we apply the theory to study the response of macrophytes in coastal marshes of Georgian Bay (GB; Lake Huron), which has experienced unusual water-level patterns with three distinct periods over the past 20 years: an initial drop to low-water levels (ILW; 2003-2007), a sustained period of extreme low-water levels (SLW; 2008-2012), and a period of high-water levels (HW; 2013-2019). Species with life-history traits best adapted to stress/disturbance should have prevailed during ILW and HW, when water levels were more dynamic, while those with life-history traits best adapted to competition should have prevailed during SLW, when water levels were more static. We combined positions of species in CSR space for 31 plant taxa with information on their form and habitat structure to explain their relative frequencies in samples collected in 42 wetlands in GB. Ultimately, we will ordinate species according to their tolerance of changing hydrological conditions to predict how novel patterns of water-level fluctuations associated with climate change will alter wetland plant assemblages.

**Emilie Montreuil Strub**[1], Rachel McNamee[1], Rebecca Rooney[2], Ryan Prosser[3], Roland I. Hall[1], Diane Orihel[4], Chelsea Rochman[5] and Gabby Izma[6], [1]University of Waterloo, Waterloo, ON, Canada, [2]Biology, University of Waterloo, Waterloo, ON, Canada, [3]University of Guelph, Guelph, ON, Canada, [4]Queens University, Kingston, ON, Canada, [5]University of Toronto Scarborough, Toronto, ON, Canada, [6]University of Waterloo, Kitchener, ON, Canada. **Can't stop, won't stop: Freshwater snail survivorship unaffected by microplastics in biofilm diet.**

Every level of the food web interacts with microplastics, but freshwater benthic invertebrate species are particularly at risk due to high microplastic concentrations in sediments. Benthic invertebrates are ecologically important, serving as prey to many aquatic and terrestrial organisms. We sought to determine the effects of environmentally relevant concentrations of prevalent microplastics on the growth and survival of *Planorbella pilsbryi*, a common invertebrate species, as well as determine the resulting microplastic body burden of surviving individuals. The novel aspect of this research was the cultivation of biofilms exposed to known concentrations of microplastics in natural environments. We fed juvenile *P. pilsbryi* cultured microplastic-contaminated biofilms over the course of two 4-week trials. Endpoints of survival and growth were measured. We assessed the surviving individuals for microplastic body burden. Preliminary results indicate that survival and growth are not affected by microplastic concentration. However, microplastics are retained in the bodies of the juveniles, with a higher body burden at higher concentrations. The accumulation of plastics in their bodies is noteworthy, not only because it has the potential to affect key functions, such as reproduction, but also because this could result in the trophic transfer of microplastics.

**Garrett Moots**, University of Toledo, Toledo, OH, USA. **The Fate of Microcystin in Recreational Lake Erie Beaches.**

While foreshore beach sands represent a potential reservoir for toxic concentrations of microcystin (MC) during algal bloom events, the concentration and persistence of MC in beach sands remains unknown. To determine the seasonal trends in MC occurrence in the beach environment, foreshore sand and lake water samples were collected from three Lake Erie beaches and analyzed by indirect, competitive ELISA. Overall, approximately 8% the of the sand and water samples exhibited MC concentrations in excess of the EPA no-contact threshold (translated from the recreational water threshold). The highest MC concentration was observed at Lake Erie Beach (Oregon, OH) (24.6 ng $g^{-1}$ sand), and was in excess of the translated EPA no-contact threshold by 3.7-fold. To determine the persistence of MC in foreshore sand, MC was added to microcosms of autoclaved and non-autoclaved sand, and incubated at 10% moisture and 30° C for 49-days, during which samples were sacrificed and subjected to ELISA analysis. Results showed that MC

concentrations decreased by 89% in autoclaved treatments (0.54 ng $g^{-1}$ $d^{-1}$) and by 99% in non-autoclaved treatments (0.65 ng $g^{-1}$ $d^{-1}$) over the incubation period, with the most rapid degradation occurring between 21 and 28 days (4.12 ng $g^{-1}$ $d^{-1}$) in non-autoclaved sands. Our results indicate that beach sand can serve as a recurring, short-term reservoir for MC and should be considered a vehicle for human exposure.

**Joshua Moraal**[1], Francine McCarthy[1], Neil Rose[2], Simon Turner[2], Nicholas Riddick[3] and Joseph Boyce[4], [1]Brock University, St. Catharines, ON, Canada, [2]University College London, London, United Kingdom, [3]York University, Toronto, ON, Canada, [4]McMaster University, Hamilton, ON, Canada. **Spheroidal carbonaceous particles in palynological preparations as proxies of anthropogenic impact.**

Spheroidal carbonaceous particles (SCPs) are a type of black carbon that are often not counted or recorded during palynological analysis. These fly-ash particles are formed from the incomplete, high-temperature combustion of fossil fuels and are transported to depositional environments downwind of their sources. They are chemically inert and not produced naturally, and thus have the potential to be a marker of anthropogenic impact. SCPs were common in palynological preparations of sediments deposited in the meromictic basin of Crawford Lake, Ontario since the mid-20$^{th}$ century as well as in samples processed using standard protocols. They were also abundant in sediments of this age in western Lake Ontario (Lan and Breslin, 1999) reflecting the rapid increase in regional fossil fuel combustion and industrial activity that has been proposed to mark the base of the Anthropocene epoch (McCarthy et al., 2023). Higher SCP concentrations were identified in palynological preparations than in preparations made following standard protocol. SCPs are being analysed from identical samples from the proposed Anthropocene paratype core archived at the Royal Ontario Museum prepared for both palynological and SCP analysis. This one-to-one comparison will provide insight on what causes the differences in SCP concentrations between the two methods.

**Hillary Morris**, Andrea Chreston, Karen McDonald and Katie Turnbull, Toronto and Region Conservation Authority, Vaughan, ON, Canada. **Adaptive management of Dog-strangling Vine and *Phragmites australis* at Tommy Thompson Park.**

Tommy Thompson Park supports a variety of vegetation communities, however the disturbed nature of the landform and its location "downstream" of Toronto makes it highly susceptible to invasive plants. Toronto and Region Conservation Authority manages 8 invasive species at the park using integrated pest management principles, and has been successful with the long-term management of Dog-strangling Vine (DSV) and Phragmites australis. In 2007, DSV was first detected in 3 small patches. Mechanical removal methods were attempted in 2009-12 without success. The infestation expanded to 7ha (predominantly monocultures) by 2013. Chemical control has been used bi-annually since 2013 and by 2021 approximately 3ha (small patches and individual stems) remained for bi-annual management to suppress spread. Phragmites australis was first detected at the restored Cell 1 wetland in 2007. By 2013, Phragmites was the dominant emergent species in the wetland and was spreading through the park. After unsuccessful mechanical removal attempts, chemical treatment began in 2018. Over 7ha of Phragmites has been managed with approximately 90% success. TRCA continues to monitor and adaptively manage the invasive plants at TTP using lessons learned through our own projects and those shared by other natural area managers.

**Igor Mrdjen**, BloomOptix, LLC, Syracuse, NY, USA. **In situ harmful algal bloom monitoring using pocket-sized, AI-Powered microscopes.**

Current methods of HAB monitoring rely heavily on laboratory analyses, sensors and/or fluoroprobe systems. These methods can prohibit frequent and efficient monitoring as they are expensive and slow. Here, we present, an accessible, AI-powered microscopy method to identify and enumerate cyanobacterial concentrations in as little as 30 seconds. In this study, digital imaging microscopes were deployed to 20 volunteers across 5 states. Volunteers collected bloom samples and images using the

provided digital microscope. Images were submitted to BloomOptix via email and app, allowing for cyanobacterial cell ID and cyanobacterial counts via the developed AI model, replacing the need for sample shipping, microscopy, and use of laborious methods. We found the BloomOpitx method to be rapid (<30 second result-turnaround), easy-to-use, and 97.5% as accurate as expert image analysis. Currently we are developing a databasing and mapping feature to our app, allowing for all data to be archived, georeferenced and used for trend analysis, allowing for proactive warnings and alerts upon ample data collection. The application of this method is envisioned to provide cost-effective, near real-time and mobile monitoring of HABs to a wide range of users, requiring only a field microscope and smart phone. Here we aim to demonstrate the vast utility of the BloomOptix system and outlook for 2023.

**Steven Mugisha**[1,2], Genevieve Ali[1] and Emmanuelle Arnaud[1], [1]University of Guelph, Guelph, ON, Canada, [2]University of McGill, Montreal, QC, Canada. **Assessing the resilience of rivers to climate change in the Lake Erie Basin.**

Climate change causes hydrological change through modifications of the flow regime of rivers. While numerous metrics can evaluate river flow responses to stressors, they do not necessarily help anticipate climate change-driven river flow modifications. Recent work showed that the coefficient of variation of flow ($CV_Q$) can help distinguish persistent river flow regimes from erratic ones, with the former being more resilient to climate change. However, this flow regime classification has not yet been applied in the Great Lakes region. Our study assessed the annual and seasonal variability of river flow regime persistence in the Lake Erie basin (LEB). Daily river flow data spanning 2011-2020 were retrieved for 59 and 74 gauging stations in the Canadian and American portions of the LEB, respectively. Annual and season-specific $CV_Q$ were computed for each station, with $CV_Q < 0.9$ signaling persistent flow regimes. Preliminary results reveal that annual $CV_Q$ values range from 0.39 to 4.1, suggesting the existence of persistent and erratic flow regimes in the LEB, with growing season $CV_Q$ values spanning a larger range (0.13-5.55) than non-growing season values (0.24-3.3). This conference contribution will focus on the spatiotemporal variability of river flow persistence and how it can guide hydrological adaptation strategies in the LEB.

**Andrew M Muir**[1], Kaitlin Almack[2], Nicholas W Boucher[1], Alexander Duncan[3], Erin S. Dunlop[4], Catherine M Febria[5], Ryan Lauzon[6], Henry Lickers[7], Bill Mattes[8], Deborah McGregor[9] and Andrea Reid[10], [1]Great Lakes Fishery Commission, Ann Arbor, MI, USA, [2]The Nature Conservancy, Toronto, ON, Canada, [3]University of British Columbia, Vancouver, BC, Canada, [4]Ontario MNRF, Trent University, Peterborough, ON, Canada, [5]Healthy Headwaters Lab, University of Windsor, Windsor, ON, Canada, [6]Chippewas of Nawash Unceded First Nation, Wiarton, ON, Canada, [7]International Joint Commission, Ottawa, ON, Canada, [8]Great Lakes Indian Fish and Wildlife Commission, Odanah, WI, USA, [9]York University, Toronto, ON, Canada, [10]Centre for Indigenous Fisheries, University of British Columbia, Vancouver, BC, Canada. **Bridging Knowledge Systems between Indigenous and non-Indigenous communities – Overview of a JGLR special issue.**

A collection of 17 manuscripts inspired by a 2021 session of the International Association for Great Lakes Research Annual Meeting was recently published as a special issue entitled: "*Bridging Knowledge Systems between Indigenous and non-Indigenous communities*." The issue brings together—in an unprecedented way—multiple knowledge systems with a focus on knowledge co-production. Collective guidance from a panel of knowledge-holders and practitioners informs wise practices for creating ethical space for knowledge co-production. Dialogue sessions and specific case studies inform frameworks for bridging knowledge systems, and highlight the importance of ceremony, language, leadership, place-based learning, and novel approaches to education. While Indigenous and Western knowledge systems differ considerably in philosophy and practice, their complementary strengths can be leveraged to benefit all. Constructs that represent bridges between knowledge systems should have the following characteristics: (1) be co-produced; (2) preserve knowledge co-existence; (3) be based in mutual understandings and respect; (4) be power-neutral; (5) be

reciprocal and non-extractive; and (6) be adaptive and open to learning and changing environments. The collection of papers on bridging knowledge systems between Indigenous and non-Indigenous communities is intended to inspire mutually beneficial collaborations for climate resiliency and sustainable stewardship of the world's great lakes.

**Mohiuddin Munawar**, Heather A Niblock and Mark A.J. Fitzpatrick, Fisheries and Oceans Canada, Burlington, ON, Canada. **Assessing ecosystem resilience in western Lake Ontario based on phytoplankton and primary productivity, 2013-2022.**

Long term seasonally intensive plankton data sets are important for understanding food web dynamics and assessing resilience. To complement lake wide cruises, nutrients and lower food web parameters from one nearshore (8m) and one offshore (60m) station in western Lake Ontario were sampled from May to October beginning in 2013. The results showed that the stations were both oligotrophic. Total Phosphorus was similar at both stations at around 15 µg/l and Chlorophyll a was 2-3 µg/l. Total phytoplankton biomass was 455 µg/l at the offshore site and slightly higher at 538 µg/l at the nearshore site. Diatomeae contributed the most (35%) to total phytoplankton biomass at the offshore site followed by phytoflagellates (Chrysophyceae + Cryptophyceae + Dinophyceae). Composition at the shallow site was more variable. Mean primary productivity was similar at both sites (5-6 mg C/m3/hr) and was dominated by nanoplankton (>40%) and picoplankton (30%). The above data plus species composition changes will be presented to discuss the continued the oligotrophication of the western Lake Ontario. The necessity and utility of long term trophic data sets to supplement the routine lake wide seasonal surveys will be emphasized.

**Lorna Murison**, Credit Valley Conservation, Mississauga, ON, Canada. **Integrated surface and groundwater chloride modeling using MIKE SHE for road salt impacts.**

Chloride, from road salt application, is a water quality parameter of growing concern in urban watersheds in cold climates. It has environmental impacts at both the acute and chronic time scales. Credit Valley Conservation's (CVC) long-term monitoring data show increasing ambient chloride at 17 of 23 stations in the watershed and real-time data have shown concentrations as high as sea water during the winter. Chloride persists in the environment, moving slowly through and often accumulating in subsurface systems. Municipalities within CVC's jurisdiction are working to increase the efficiency of their road salt application while maintaining safety. However, because of the conservative nature of chloride, it may take many years before changes in management practices are reflected in surface water chloride concentrations. Therefore, we developed an integrated surface and groundwater watershed model (MIKE SHE) to simulate chloride concentrations in one of our urbanizing watersheds. The model is calibrated to existing conditions using high resolution chloride data measured at one of CVC's 11 real-time water quality stations. Using high frequency data ensures that true peak chloride concentrations, daily patterns of dilution and concentration, and seasonal variations are accurately represented. The calibrated model will be run for different road salt application management scenarios to evaluate their benefits. Results will be presented at the conference.

**Eoin Murray** and Simon Bluett, Aquamonitrix Ltd., Carlow, Ireland. **Robust off-grid analyzer for autonomous remote in-situ monitoring of nitrate and nitrite in water.**

An off-grid, internet-of-things (IoT) connected ion chromatography analyzer for the real-time automated measurement of nitrate and nitrite levels in remote surface water applications is discussed. Rapid ion separation and selective detection of nitrite and nitrate is achieved using a 235 nm UV-LED detector. The system incorporates a self-cleaning 3D printed Sediment Trap to filter sample before analysis, preventing silt and sediment from causing blockages and facilitating robust performance during long-term deployments. The *in-situ* analyzer has been shown to deliver lab-quality analytical performance in the field. Several deployments of the analyzer to monitor surface waters within remote locations in Ireland are

highlighted and discussed. Through the deployment of this new *in-situ* analyzer, transient pollution events were detected, facilitating improved water-quality management of remote water catchments. All deployed analyzers were monitored in real-time using a cellular IoT module and cloud-based dashboard.

**Mary Muter**, Georgian Bay Great Lakes Foundation, King City, ON, Canada. **Community volunteers work together with researchers and a local municipality to improve nearshore water quality.**

As a shoreline property owner, I have a strong interest in protecting the quality of nearshore waters of Georgian Bay to ensure its safety for drinking and swimming, and to maintain property values. During the 1990s, I was one of several cottagers who approached the municipal council to fund a volunteer-based monitoring program to track the presence of *E. coli*, an indicator of fecal contamination. Over the 10 years of monitoring, we identified many hotspots with elevated bacteria counts. We trained many volunteers and educated the public about the need for regular septic-system inspections and maintenance. The hotspots were mostly in areas where there were marinas and dense trailer camp/cottage development. Related to our volunteer water-quality sampling, there were concerns about algal growth along the shorelines, especially in enclosed bays. We then began collecting samples for total phosphorus and found elevated levels in channels leading into enclosed bays. Since algae usually formed after high winds had subsided, we knew that weather also influenced algal activity. In 2020, we partnered with Dr. Chow-Fraser at McMaster to improve the testing and to determine if the bacteria in hotspots have a human or animal source. The goal is to approach the provincial and municipal governments with proof of sewage contamination to initiate inspection of leaking septic systems installed on granite bedrock.

**Spencer Myers**, Bowling Green State University, Bowling Green, OH, USA. **The City and the Lake: Sociospatially Situating the Lake Erie Bill of Rights.**

In 2014, Toledo, Ohio residents were issued a do-not-drink advisory due to a Lake Erie algal bloom caused by warmer than usual water temperatures and pollution due primarily to climate change and farm run-off (Ames et al. 2019). In response, a city-wide referendum to establish a Lake Erie Bill of Rights (LEBOR) was passed in 2019. It was struck down in court a year later for being vague and broadly applied. My community-based research focuses on interviewing the activists behind the LEBOR to understand their collaborative composition process and rhetorical decisions along with the legacy of the document that resulted. The LEBOR ultimately relied on citizens of Toledo being given the right to sue on the Lake's behalf. This connection to one specific place and its residents requires my research to map the contemporary spaces corresponding to the composition process while attending to the ongoing palimpsest composed of indigenous lives and the Great Black Swamp. This means interweaving the words of the activists with theories of spatiality (Lefebvre 1974)(Reynolds 2004)(Harvey 1997), spatial cognition (Levinson 2003), and placemaking (Tuan 1977) all while troubling how naturecultural work like the LEBOR can flatten power dynamics between humans and nonhumans (Clary-Lemon 2019)(Vetlesen 2019) and between colonizers and those we continue to oppress (King 2019)(Na'Puti 2019).

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David Cannon[1], Abby Hutson[2], Ayumi Fujisaki-Manome[3], Jia Wang[4] and **Miye Nakashima**[5], [1]CIGLR, Cooperative Institute for Great Lakes Research, University of Michigan, Ann Arbor, MI, USA, [2]CIGLR, University of Michigan, Ann Arbor, MI, USA, [3]Cooperative Institute for Great Lakes Research, University of Michigan, Ann Arbor, MI, USA, [4]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, USA, [5]University of Michigan, School for Environment and Sustainability, Ann Arbor, MI, USA. **Assessing biases in climate models and atmospheric reanalysis datasets in the Great Lakes.**

In this study, we assess biases in historical atmospheric reanalysis datasets and CMIP6 climate models in the Great Lakes region. While model validation is generally conducted on continental scales (i.e. North America), spatial differences in model accuracy can lead to large biases in forcing variables (i.e. air temperatures, wind speeds, etc.) over smaller regional scales. Choosing forcing datasets with lower regional biases can provide better boundary conditions for local climate downscaling and improve the accuracy of hydrodynamic lake models, which we show are strongly influenced by biased air temperatures and wind forcing. Forcing variables from several popular reanalysis datasets (NARR, ERA5, HRRR, CFSR) and CMIP6 climate models (GFDL-CM4, GFDL-ESM4, ECEarth3, IPSL, etc.) are compared to observations across the Great Lakes region, providing estimates of seasonal errors (e.g. RMSE) and biases (e.g. MBE) on each lake. We find that modelled air temperatures are often biased warm in the summer (+1 – 5 C), with severe cold biases in the early winter and late fall (-1 – 10 C). CMIP6 models are further compared to the best performing reanalysis dataset (ERA5), providing spatially explicit estimates of errors above land and water. Results are used to identify best-performing CMIP6 models, with discussion of future work on model downscaling and climate projections.

**Caroline Nampemba**, AWIS, City, Zambia. **The potential of aquaculture development on Lake Tanganyika.**

Zambia's abundant water resources can be used for aquaculture development. Lake Tanganyika can play a significant role in aquaculture to bridge the gap between demand and supply in the country. In Zambia, the Lake represents a significant source of food and livelihood for people dwelling within the basin (FAO, 2012) and it is home for many aquatic organisms. However, due to climate change, population growth and increasing dependence on fisheries, the lake faces a number of challenges including overfishing through the use of unsustainable fishing methods by the local communities, leading to decline in catches and degradation of the aquatic ecosystem(Haambiya eta.,2015). The level of fishing pressure on the Lake has triggered the need to accelerate the development of strong complementary technologies in aquaculture production systems such as cage fish culture. This study will aim at assessing the potential of aquaculture development on Lake Tanganyika for small scale fishers which will be directed towards combating the effect of climate change and supporting livelihoods in the region. The assessment will be based on literature reviews, interviews with experts on fisheries management and the village conservation and development committees as well as other stakeholders. Results will be analysed using SWOT to analyse the potentiality of culturing fish on the Lake.

**Ashlyn Nance**[1], Katerina Carrozii[1], Yuying Chen[1], Thy Doan[1], Mary Long[1], Ishani Sharma[1], Zoe UngkuFa'iz[1], Susan Debreceni[1], Rafaella Gutierrez[1] and Chelsea Rochman[2], [1]University of Toronto, Toronto, ON, Canada, [2]University of Toronto Scarborough, Toronto, ON, Canada. **Trapping Trash on Toronto's Waterfront: a monitoring tool for simultaneous cleanup and data collection.**

Trash capture devices are great tools for cleanup, monitoring, and outreach. In Summer 2022, in collaboration with PortsToronto, TRCA, Swim Drink Fish, and the City of Toronto, we deployed 10 Seabins and 10 LittaTraps. During the summer, 7 student researchers quantified and characterized anthropogenic debris in all traps deployed in the Toronto Harbour and the Outer Harbour Marina. In addition, with the Waterfront BIA, we skimmed anthropogenic debris from slips that did not have traps, but had large accumulations of litter. Overall, we diverted 118 kg of anthropogenic debris, including plastic pollution, from Lake Ontario. This includes ~100,000 pieces of small plastic, 2mm – 2.5cm in size. Aside from large pieces of plastic film, fragments, and foam, our top items included cigarette butts, construction foam, plastic food wrappers, plastic bags, plastic pre-production pellets and plastic bottles. This data helps us identify sources of plastic into our watersheds to inform prevention policies. Finally, we interacted with the public as they passed by and ran community science events where the public could quantify and characterize our collections alongside us. We demonstrate the value of trash trapping as a monitoring tool with the added benefit of cleanup and informing prevention of plastic pollution on the Great Lakes.

**Angela Nankabirwa**[1], Pete Mcintyre[1,2], Horace Onyango[2,3], Eric Matthew Teplitz[4] and Kathryn Fiorella[4], [1]Department of Ecology and Evolutionary Biology, Cornell University, Ithaca, NY, USA, [2]Department of Natural Resources and the Environment, Cornell university, Ithaca, NY, USA, [3]Kenya Marine and Fisheries Research Institute, Kisumu, Kenya, [4]College of Veterinary Medicine, Cornell University, Ithaca, NY, USA. **Are algal bloom occurrences in Lake Victoria harmful to the fisheries and community?.**

Lake Victoria has for a long time been considered eutrophic with degrading water quality, as shown by occurrence of harmful algal blooms (HABs). These blooms have been attributed to Microcystis, a genus increasingly known worldwide for producing toxins that cause fish kills, leading to socio and economic losses. Despite the importance of HABs, knowledge of their occurrence, extent, and consequences on fish and human health is still limited. This study investigated microcystin concentration (MC) in water and fish along an algal bloom gradient during July 2022 in Nyanza Gulf, on the north-east part of Lake Victoria. Preliminary results based on chlorophyll a showed that in a single day, samples from a suite of sites can represent a gradient from heavy, sustained blooms to non-bloom areas, and that these patterns are only weakly related to differences in nutrient availability. Statistical analyses suggest that the spatial differences among sites in algal concentrations are relatively stable in time. In the next few weeks, I will complete microcystin analysis of water and fish samples, and I will also use carbon and nitrogen isotope analysis to compare the diets of three fish species to determine the ecological basis for any differences in MC contamination among species. This study will advance our understanding of what causes HABS, and how their environmental and societal impacts could be reduced.

**Kayden C Nasworthy**[1], James M Watkins[1], Lars G. Rudstam[1], Thomas M Evans[2], Sarah Diane Lawhun[2], Suresh A. Sethi[2], Timothy P O'Brien[3], Steven A Farha[3], David M Warner[3] and Peter C Esselman[3], [1]Cornell Biological Field Station, Bridgeport, NY, USA, [2]Cornell University, Ithaca, NY, USA, [3]U.S. Geological Survey, Great Lakes Science Center, Ann Arbor, MI, USA. **Abundance of *Mysis diluviana* in Lakes Michigan and Huron assessed using acoustic data from autonomous vessels.**

*Mysis diluviana* (hereafter *Mysis*) are important prey items for many fishes due to their large size, high lipid content and abundance. Long-term monitoring using traditional net tows have detected a decline in the *Mysis* population in Lake Michigan since 2015. However, net tow surveys are limited to discrete sampling sites and cannot resolve the vertical distribution of *Mysis* in the water column. In contrast, acoustic surveys can provide more extensive spatial data and provide insight into vertical distribution, allowing more robust estimates of lakewide abundance. In August and September 2021, two Saildrones (uncrewed surface vessels) outfitted with 120kHz Simrad EK80 transducers were deployed in Lakes Michigan and Huron and sampled continuously for 47 days. Volume backscattering (Sv) and target strength (TS) data were used to define a nighttime *Mysis* layer, with a mask applied to filter out backscattering values from fish. The nighttime *Mysis* layer was distinct and had few fish targets within it. There was a positive relationship with increasing site depth and higher *Mysis* density. Data collected from additional Saildrone deployments in the Great Lakes will provide valuable insight into the abundance and distribution of *Mysis*.

**Kundananji Nawanzi**, Citizens Economic Empowerment Commission, Ndola, Zambia. **Water pollution and its effect on fish production of Lake Tanganyika, Zambia.**

Water pollution is one of the most serious challenges in the aquatic environment regardless it being a vital component in making the life processes possible.Pollution maybe as a result of natural or anthropogenic activities leading to chemical or biological water contamination. Analysis of these contaminants can give an overall pollution levels in the waterbody. Therefore, this study will aim at:a). assessing the concentration levels of biological (pathogenic bacterias, viruses, parasites) and heavy metals (Pb,Cd, Ni, Cr, Cu, Zn, Mn,As) contamination in the water of lake Tanganyika, Zambia; b) and determine their effect on the early development, growth and reproduction of fish. Lake Tanganyika is the second largest lake in the world and is shared by Burundi, Tanzania, DRC and Zambia with about 250 cichlid endemic fish species. This study will analyse the pollution levels on the zambia part of the Lake, in

Mpulungu district which will act as a reference point in the sustainable management of the lake as it contributes significantly to the socio-economic wellness of the community and the nation at large. Water samples will be collected using a 1L polythene bottles according to the modified procedure of Khan et al. (2018) and Cornell et al. (2016). Samples will be acidified with nitric acid to avoid external contamination and transported to the laboratory using the Flame Atomic Absorption Spectrophotometer (AAS:model PinAAcle 500, PerkinElmer Inc., Shelton, USA) in accordance with the American Public Health Association method and standards (APHA, 2012).

**Lauren Nawroth**[1], Lyndsay Cartwright[2], Allison Rutter[1] and Barbara Zeeb[3], [1]Queen's University, Kingston, ON, Canada, [2]Toronto and Region Conservation Authority, Vaughan, ON, Canada, [3]Royal Military College of Canada, Kingston, ON, Canada. **Turning A New Leaf on Salinization: Phytoremediation of Contaminated Soils Using Halophytes.**

Salinization of soils, surface- and groundwater are increasingly being identified as environmental concerns. In Canada, there are many sources of chloride contamination. As one of the largest users of road salt worldwide, Canada distributes over 5 million tonnes of this material each year. The copious amounts of salt applied to roads in winter have lasting effects in ecosystems located roadside and beyond, including the summer months. Other notable sources of chloride contamination in Canada include oil and gas production, and the production of saline material from various industries. Traditional methods of chloride remediation are often costly and labour intensive with negative impacts on the environment due to the generation of by-products, accelerated soil erosion, and edaphic soil conditions. Phytoremediation utilizing halophytes (i.e. salt tolerant plants), is being investigated as a way of remediating salt-impacted areas. Previous greenhouse and small-scale *in situ* studies have shown significant reductions in soil salinity using halophytes. In this study, native Canadian halophytes are being evaluated for their abilities to remediate salt contaminated soils at two different field sites. One site is located in a large metropolitan area where roads are treated with salts throughout the winter months for safety reasons. The second site is an industrial location previously used for petroleum extraction. The contrasts of the two field sites will allow for a comprehensive analysis of halophytic abilities in large-scale remediation applications.

**Behnam Nayebi**[1], Rama Pulicharla[1], Reza Valipour[2], David C Depew[3], Shooka Karimpour[1] and Satinder Kaur Brar[1], [1]Department of Civil Engineering, Lassonde School of Engineering, York University, North York, Toronto, Ontario M3J 1P3, Canada, Toronto, ON, Canada, [2]Environment and Climate Change Canada, Burlington, ON, Canada, [3]Environment and Climate Change Canada, Water Science and Technology Branch, Canada Centre for Inland Waters, Burlington, ON, Canada. **In-depth Variability of Microplastics in Hamilton Harbour.**

Hamilton Harbor is identified as one of the Areas of Concern due to degradation in water and sediment quality. The formation of the thermocline, caused by temperature-induced stratification, has been shown in lakes to affect water quality indexes. These include changes in pH, dissolved oxygen, and turbidity, among other factors. This study aims to investigate the distribution of microplastics (MPs) in Hamilton Harbor. MPs aren't passive contaminants; their density actively affects their in-depth distribution. Combined with mixing caused by the thermocline formation, they will affect the distribution of MPs in Hamilton Harbor. To conduct the research, bulk water samples were collected from Hamilton Harbor at different times of the year with various expected thermoclines. Also, in-depth dispersion profiles were collected using MicroCTD. Water samples then are filtered, and various preparation methods were used, including digestion and filtration. The prepared samples were then analyzed using microscopy techniques and were categorized based on their size, shape, and color. Furthermore, using an advection-diffusion model, the possible distribution of the MP contaminant particles is simulated, implementing the in-situ dispersion profiles. Using this method allowed for a more detailed analysis of the samples and provided additional information about the composition of the MPs found in the water. Combined with the results of the numerical simulations, this study assesses the role of MP characteristics and stratification in their in-depth distribution.

**Alex Neumann**[1], Agnes E. Blukacz-Richards[2], Ratnajit Saha[1], Carlos Alberto Arnillas[1] and George B. Arhonditsis[1], [1]Ecological Modeling Laboratory, Department of Physical and Environmental Sciences, University of Toronto, Toronto, ON, Canada, [2]Environment and Climate Change Canada, National Water Research Institute, Burlington, ON, Canada. **Application of SPARROW model to examine phosphorus export between contrasting flow regimes in southern Georgian Bay.**

We applied a SPARROW-based empirical watershed model to assess regional total phosphorus (P) export coefficients that can assist with nutrient mitigation projects and support adaptive watershed management. Limitations in the number of tributary monitoring stations were overcome by assembling multi-agency water quality data and extending the study area to include Lake Simcoe Region, Nottawasaga Valley and Grey Sauble Conservation Authorities. To analyze tributary nutrient loading during different flow regimes, such as dry and wet years, we applied a Bayesian hierarchical framework. Agriculture was identified as a major non-point P source representing between 30 and 48% of the delivered P loading. Our source apportionment predicted P loss rates from croplands that exceeded those from forested areas by 320% during dry years and by 360% during wet years, while low intensity agricultural areas (hay and pasture) exceeded P export from forests by a mere 20% and 30%, respectively. Our study identified urban runoff as another significant non-point nutrient source displaying the highest variability between dry and wet years. P export rates from urban areas were 3-4 times higher than those in intensive agriculture during high flow regimes. Importantly, owing to the massive urbanization in the Lake Simcoe watershed, urban runoff contributed nearly half of the delivered P loading from the tributaries into the lake. As a result of our analysis, we emphasize the importance of mitigating urban non-point sources as well as controlling agricultural runoff.

**Thu Hang Nguyen**, Fereidoun Hang Nguyen, Amir Reshadi, Stephanie Slowinski and Philippe Van Cappellen, Ecohydrology Research Group, University of Waterloo, Waterloo, ON, Canada. **Controls on microplastics accumulation in stormwater pond sediments: Preliminary results.**

In urban watersheds, stormwater runoff is a major carrier of microplastics to downstream water bodies. The existing evidence indicates that stormwater ponds (SWPs) may be very effective at reducing the export loads of microplastics from urban areas. However, the effectiveness of SWPs in retaining different microplastic types and size classes remains understudied. The aims of this study are to (1) assess the variability in accumulated in SWP sediments, (2) determine the influence of sediment properties on microplastics accumulation in SWPs, and (3) relate microplastics loads in stormwater runoff to upstream land use and land cover (LULC). We collected sediment samples from five SWPs with different LULC (commercial, industrial, and residential) in the City of Kitchener, Ontario. Preliminary results at one of the ponds draining an industrial area show that microplastic fragment accumulation rates decreased from $9x10^7$ particles $m^{-2}$ $yr^{-1}$ in the inlet forebay to $2x10^7$ particles $m^{-2}$ $yr^{-1}$ in the main basin. Moreover, industrial ponds exhibited the highest sediment burial and organic carbon accumulation rates, followed by ponds receiving stormwater from residential and commercial areas. This study sheds light on the contribution of urban catchments to microplastic pollution and the factors controlling microplastics retention by SWPs.

**Vivian M Nguyen**[1], Mahatub Badhon[2], Christine Beaudoin[3], Leandro Castello[2], Jeanne Coffin-Schmitt[4], Steven Cooke[1], Katie Fiorella[5], Aaron Fisk[6], Elizabeth Nyboer[7], Richard Stedman[4], Nicole Tu-Maung[4] and Aaron MacNeil[8], [1]Carleton University, Ottawa, ON, Canada, [2]Virginia Tech, Blacksburg, VA, USA, [3]Universite de L'Ontario Francais, Toronto, ON, Canada, [4]Cornell University, Ithaca, NY, USA, [5]College of Veterinary Medicine, Cornell University, Ithaca, NY, USA, [6]School of the Environment, University of Windsor, Windsor, ON, Canada, [7]Centre for Indigenous Fisheries, University of British Columbia, Vancouver, BC, Canada, [8]Dalhousie University, Halifax, NS, Canada. **Provisioning Fisheries: Calling Attention to Non-Recreational Dimensions of Recreational Fisheries.**

Provisioning fisheries are distinct from recreational fisheries in that provisioning fishers are not primarily fishing for fun but are reliant on this activity for its multi-dimensional values and services. Often,

recreational anglers practice catch-and-release, but will also harvest their catch for multiple reasons which may often be overlooked, including reasons beyond leisure such as cultural practices, contribution to livelihood strategies, offset food costs, and provide a healthy protein choice, among other motivations. We argue for researchers and managers to consider a potential modality, or even new class, of recreational fisheries that we term 'provisioning fisheries'. Provisioning fisheries are multi-dimensional and provide a combination of recreational, cultural, social, economic, identity and sense of place, health and wellbeing, and nutritional values to people accessing these fisheries. We propose that this modality should either be considered as part of the recreational fisheries portfolio to promote more sustainable and inclusive fisheries management as we hypothesize that angler behaviour and catch composition are distinct from more conventional recreational fishers. We put forward a research framework, along with a short synthesis of what we currently know about provisioning fisheries to encourage greater dialogue and investigation about a marginalized fishery to promote more inclusive and sustainable fisheries management.

**Heather A Niblock**, Mohiuddin Munawar, Mark A.J. Fitzpatrick and Warren J.S. Currie, Fisheries and Oceans Canada, Burlington, ON, Canada. **Exploring Phytoplankton community structure, primary and bacterial productivity in the urbanized Toronto Harbour.**

Toronto Harbour is a highly urbanized embayment with a history of eutrophication due to municipal wastewater and stormwater runoff. Although nutrient levels have decreased since the 1970s and the harbour is considered mesotrophic, wet weather conditions flush high concentrations of nutrients from the watershed into the harbour. Starting in 2016 seasonal patterns in phytoplankton community structure and primary productivity were measured. In 2019 phytoplankton biomass averaged 0.7 g $m^{-3}$ at the centre station and 1.3 g $m^{-3}$ at the Don River station. Diatoms were often the highest contributors to biomass but Chrysophyceae and Cryptophyceae were also important. Seasonal productivity rates averaged 14 mg C $m^{-3}$ $hr^{-1}$ in the central harbour compared to 22 mg C $m^{-3}$ $hr^{-1}$ near the Don River. Bacterial productivity near the Don River averaged 3.3 mg C $m^{-3}$ $hr^{-1}$ , more than twice the central harbour value. This indicates that a considerable amount of organic matter is being deposited into the harbour from the river. The presentation will discuss how the Don River impacts phytoplankton and bacterial dynamics in Toronto harbour.

**Asante Nkhata**, 1Pact Malawi, Restoring Fisheries for Sustainable livelihoods in Lake Malawi (REFRESH) project, Lilongwe, Malawi. **Community Participation in Ecosystem Based Fisheries Management in Restoring Lake Malawi Fish Biodiversity.**

Lake Malawi with over 700 endemic fish species boasts about having the greatest fish biodiversity than other freshwater lake in the world. The lake offers services that are socio-economically important to many fishing communities, traders, researchers, tourists etc. However, overpopulation, unsustainable fishing practices and habitat destruction have significantly reduced fish stocks particularly the economically important species like Chambo. Restoring Fisheries for Sustainable livelihoods in Lake Malawi (REFRESH) Project is making new efforts by increasing resiliency to climate change and improving biodiversity conservation through effective and sustainable fisheries management. Through the adoption of the Ecosystem Based Fisheries Management (EBFM) system, the project is engaging communities in finding solutions to the current fisheries management challenges. Establishment and management of breeding areas (sanctuaries) is one of the key areas that the communities are implementing following successful development of fisheries management plans and their subsequent by-laws. Communities are also conserving immediate terrestrial ecosystem, especially vegetation along Lake Malawi and tributaries. The community engagement in the fisheries resource management has brought many success stories that include increased sense of ownership, active participation and establishment of conservation enterprises that shifts focus of the communities away from the fisheries resource exploitation.

**Shayenna-Rae Nolan**, Daniel Heath and Catherine Febria, University of Windsor, Windsor, ON, Canada. **Stream health and controls on the complexity of dissolved organic matter in settled and Indigenous landscapes.**

Indigenous peoples have been altering landscapes and coexisting with nature for millennia, but in the era of the Anthropocene, the advent of settler-colonialism and the conversion of lands through urbanization and agriculture has shifted the balance from coexistence to exploitation, severely impacting ecosystems. Stream ecosystems, particularly headwaters, are uniquely affected due to their reliance on energy inputs (i.e., carbon) from the landscape, which include dissolved organic matter (DOM) derived from terrestrial plant material. Here we describe a novel stream assessment involving molecular and cultural indicators. At a regional scale (n=7), we showed DOM quality reflected land use more effectively than macroinvertebrates or decomposition. This effect was further investigated in the current study at a broader landscape scale in the highly settled province of Ontario, Canada (n=116), where DOM was significantly affected by land use and varied predictably with stream health. Explorations of stream health in Indigenous-managed watersheds will use DOM as well as co-produced, culturally informed assessments to conduct biomonitoring in alignment with community values and priorities. In the post-2020 Global Biodiversity Framework, where Indigenous Peoples play a crucial role in its' successful implementation, this research seeks to uplift and empower Indigenous knowledge and communities in the monitoring and care of freshwater.

**Richard K Norton**, University of Michigan, Ann Arbor, MI, USA. **A Conceptual Framework for Studying and Contributing to Great Lakes Coastal Management Decision-Making.**

Most Great Lakes coastal shorelands are privately owned. Governments play an important role in managing the development and use of those shorelands to conserve the natural and social resources they encompass. Natural scientists have demonstrated that imprudent shoreland use is yielding significant ecological harms to coastal habitats and growing risks to coastal properties, and they have called for improved public planning for those shorelands. Planning researchers have focused on improving plan-making methods and processes, but less so on improving plan implementation. Both recognize the benefits of co-producing natural and social-scientific knowledge, but neither has situated fully the ways in which decision-makers' knowledge, capacities, and motivations interact to influence coastal management decision-making outputs and outcomes. Synthesizing multiple literatures, this paper presents a conceptual framework to assist scholars wanting to ensure their knowledge contributes meaningfully to coastal management decision-making or looking to contribute to improved decision-making through collaborative research. Set within the institutional arrangements that structure public coastal management processes, the framework highlights the ways in which key decision-makers' attributes influence the decisions they make.

**Gertrud K. Nurnberg**, Freshwater Research, Baysville, ON, Canada. **Cyanobacteria response to climate-affected internal phosphorus loading in two drinking water reservoirs.**

Phosphate released from bottom sediments can present a nutrient source for cyanobacteria in late summer and fall in two low-productive drinking water reservoirs of the City of Moncton, New Brunswick. Phosphorus (TP and dissolved P) and metal depth profiles, their seasonal changes, and sediment P fractionation indicate internal P release from anoxic sediment in 6 study years Since 2017, internal load was up to 28% of total TP load in the upstream and up to 12% in the downstream reservoir. Phytoplankton (measured by sensor profiles of chlorophyll and phycocyanin, Secchi transparency, and cell counts) responded to internal P load, but were also affected by climate conditions. As expected, cyanobacteria proliferated in dry and warm summers (low daily precipitation and high maximum air temperature in Jun-Sep) that also provided sufficient P released from sediments, but were further influenced by reservoir mixing status as controlled by reservoir elevation. In addition, major precipitation and storm events enhanced water column fertilization by early mixing, but could also shorten potential bloom periods. The observed short-term weather variability and expected long-term climate effects (warmer and more disturbed

weather patterns) complicate any forecasts of cyanobacteria proliferation in these reservoirs in response to internal P sources. A physical approach to remediation involves the increase of the upstream dam height and is based on theoretical limnological considerations and TP mass balance modeling.

**Olivia Nyffeler**[1], Gretchen JA Hansen[1] and Lynn Waterhouse[2], [1]University of Minnesota, St. Paul, MN, USA, [2]Minnesota Fish and Wildlife Cooperative Research Unit, University of Minnesota, St. Paul, MN, USA. **Investigating Drivers of Cisco Recruitment in Lake Superior.**

The Great Lakes have historically featured high abundances of Cisco (*Coregonus artedi*), but by the 1970s stocks in all the lakes had collapsed. Populations appear to be steadily increasing in Lake Superior, but contemporary abundances are still below previous numbers. The declines in the mid-1900s were a result of anthropogenic influences such as overfishing, pollution, and invasive species introductions. Despite recovering stocks, recruitment is sporadic and the relationship between adult stocks and year-class strength is not yet fully understood. Our goal is to understand the abiotic and biotic factors driving Cisco recruitment in Lake Superior; we plan to use three quantitative models to investigate each hypothesized driver influencing recruitment including 1.) Multivariate Auto-Regressive State Space Models 2.) Empirical Dynamic Models, and 3.) Bayesian Spatial Delta-glmm models. We hypothesize that late falls, shorter winters, and early springs will negatively impact Cisco recruitment. We also expect to find recruitment will be negatively impacted by abundances of non-native species and other competitors. To date, we are collecting datasets and investigating hypotheses currently available in the literature and from Cisco experts to further identify further drivers.

# O

**Kevin Odhiambo Obiero**[1], **Sandra Klemet-N'Guessan**[2], Ajode Zephaniah Migeni[3] and Achieng Alfred Otieno[4], [1]Kenya Marine and Fisheries Research institute, Pap-Onditi, Nyanza, Kenya, [2]Trent University, Peterborough, ON, Canada, [3]African Center for Aquatic Research and Education, Ann Arbor, USA, [4]University of Eldoret, Eldoret, Kenya. **Bridging Indigenous and non-Indigenous knowledge systems for the sustainable management of African fresh waters.**

Indigenous peoples are the custodians of some of the world's most biologically diverse territories. Aside from being responsible for much of the world's linguistic and cultural diversity, their traditional knowledge has been, and continues to be, an invaluable resource for all of humanity. Nonetheless, their norms, belief systems, languages, and ways of life are under threat, sometimes even extinction. For example, colonization and the introduction of non-Indigenous practices suppressed traditional knowledge and cultural heritage, which was a long-term and cumulative understanding of these ecosystems' dynamics. In this study, we review the cultural and spiritual practices that have shaped Indigenous resource use and techniques in the conservation and management of aquatic ecosystems in East and West Africa, identify challenges to Indigenous knowledge systems within the current Western scientific framework, and suggest best practices in research and management that combine Indigenous and non-Indigenous approaches. We recognize that, while mainstream approaches to ecosystem management have scientific backing, community understanding and perspectives in catchment resource management are critical considerations that must be incorporated into mainstream approaches to ecosystem management. Our study concludes by emphasizing the critical need to pair traditional knowledge with scientific approaches for improved aquatic resource management and by providing recommendations to bridge Indigenous and non-Indigenous knowledge systems.

**Nicole O'Brien**[1], Frank Seglenieks[2], Lauren M Fry[3], Deanna Fielder[4] and Andre Temgoua[5], [1]National Hydrological Service, Environment and Climate Change Canada, Dartmouth, NS, Canada, [2]National

Hydrological Service, ECCC, Burlington, ON, Canada, [3]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, USA, [4]U.S. Army Corps of Engineers Detroit District, Detroit, MI, USA, [5]Environment and Climate Change Canada, Quebec City, QC, Canada. **Creation of a coordinated Great Lakes dataset of Net Basin Supply and Components.**

Currently available coordinated estimates of net basin supply (NBS), referred to as residual NBS are developed based on lake level measurements and flow into and out of each lake. Efforts have been underway to develop a coordinated historical dataset of component NBS and its associated water balance components, which include precipitation, evaporation, and runoff for each of the Great Lakes Basins. Certain aspects of the Great Lakes Basins water balance are challenging to measure, given the size of the lakes and the scarcity of monitoring stations within the watersheds. To overcome this challenge, the Large Lakes Statistical Water Balance Model (L2SWBM) is implemented, which estimates the Great Lakes Basins water balance components using a Bayesian Markov chain Monte Carlo framework, while closing the water balance. The L2SWBM model provides reliable estimates of precipitation, evaporation, runoff, and component NBS. These modelled water balance component datasets provides consistent data, overcoming the issue of measurement bias over time, thus facilitating historical comparisons and trend analyses. A first version of these coordinated datasets have been developed from the L2SWBM output from 1955 to 2021 and will be publicly available.

**Katie O'Reilly**, Illinois-Indiana Sea Grant / Illinois Natural History Survey, Champaign, IL, USA. **How the Grinch stole #Fishmas: Invasive species communication within a broader biodiversity campaign.**

Storytelling can be a powerful tool to help audiences understand, process, and recall science-related information, particularly for complex environmental challenges like invasive species in the Laurentian Great Lakes. While every good story needs a villain and non-native species seem like obvious antagonists, it is unclear how that framing may affect public awareness of and support for invasive species management. Using a social media campaign I created to increase awareness of fish diversity in the Great Lakes (#25DaysofFishmas), I examine how Twitter audiences engage with information about non-native compared to native fish species. A recurring narrative frame in the campaign is that of non-native species being "Grinches," that is, "stealing" the joy of the holiday. Tweets featuring non-native species received slightly fewer likes on average than those featuring native species, but factors not associated with native status (e.g., use of images) had greater effects on measures of engagement. Beyond increasing awareness of specific non-native species, I show how the use of social media also provides unique opportunities to discuss why some non-native species are not considered as "invasive" (e.g., Pacific salmonids), as well as for dispelling myths about native species look-alikes (e.g., suckers and carp). Because the story of the Great Lakes can't be told without non-native species, I discuss ideas on how to frame social media messaging to clearly communicate the potential harm some non-native species may pose while avoiding demonization.

**Harriet Atieno Okeyo**, Fish Biology Research Intern, Kisumu, Kenya. **Fish waste to resource management to reduce eutrophication.**

Lake Victoria faces eutrophication challenges which has seen water quality deteriorates and fish stocks reduce. The nutrient loading that leads to eutrophication originates from autochthonous and allochthonous sources and includes human wastes, industrial wastes, and fish wastes resulting from fish processing. This study aims to reduce eutrophication in Lake Victoria by converting fish wastes to value-added products thus reducing algal bloom and the community's exposure to the harmful toxin produced by the blooms. The project will involve waste to resource approach where fish wastes will be mapped out, collected and transported to central place where they will be converted to the value-added product which will include fish oils from offals, gelatin from skin and chicken feeds. Dissemination of production technology will be carried out to create jobs and as an effort to bring more people to uptake fish wastes from the environment. Preliminary results indicate that microcystin level goes above the recommended level

during bloom, the local communities use water directly for their domestic use including drinking, one sampled market in Kisumu town produces 800kg of waste per day, and fish wastes contribute three-fold the concentration of nutrient (nitrates, nitrites, ammonium) produced by human wastes into the lake. The success of the project will be analyzed by tabulating the number of youths involved in the waste of resources in small community groups and the quantity of value-added products produced per month. In conclusion, this will reduce the quantity of waste.

**Alex Okolocha** and Anthony Okoye, Nnamdi Azikiwe University, Awka, Nigeria. **Emerging contaminants, PFAS under climatic variability: Insights from Agulu Lake, Nigeria.**

Emerging contaminants, including poly-fluoroalkyl substances—PFAS, remain among the greatest threats to freshwater ecosystems worldwide. Despite the increasing recognition of their effects on freshwater integrity, monitoring these contaminants in Africa, including Nigeria, remains scarce. We provide a preliminary insight into the presence and distribution of PFAS under varying climatic conditions in Agulu Lake, Anambra State, Nigeria. We sampled 10 Perfluorinated Carboxylic Acids (PFCAs), 5 Perfluorosulfonic Acids (PFSAs), 5 Fluorotelomers, 5 Perfluoroalkyl Sulfonamides (FASAs), and 3 Perfluoroalkyl Sulfonyl Amide Acetates in eight sites across the dry, wet and harmattan seasons between 2019 and 2021. Sites were also selected to reflect varying land-uses, including agriculture, informal settlements and industry. Results showed that all analysed PFAs were detected in all sites. The concentrations of PFAS detected ranged from 0.05–2.21µg/L across the sites and seasons. Seasons were more influential in shaping the distribution of PFAS in the study area than sites. The informal settlement has higher concentrations (2.22µg/L) of PFAS than agriculture. The highest concentration of PFAS was Perfluorohexanesulfonic Acid (PFCAs—1.99 µg/L), followed by Perfluorohexanesulfonic Acid (PFHxA) (0.30µg/L), and Perfluorooctanesulfonic Acid (PFOS) (0.22µg/L). The findings of this study provided baseline data and can contribute towards developing an effective regional strategy for managing PFAS influence in freshwater ecosystems in Nigeria

**Jason Olsthoorn**, Civil Engineering, Queens University, Kingston, ON, Canada. **Modelling convection with a variable surface temperature.**

Precisely measuring the surface temperature of a lake is challenging and is typically unavailable. However, the surface temperature is necessary to accurately predict the surface heat fluxes. This talk presents a framework to understand how the surface temperature can be estimated from the convection within a lake. Numerical and laboratory data will be presented to demonstrate the feasibility of the method.

**Zadock Ochieng' Omach**, Kenya Marine and Fisheries Research Institute, Kisumu, Kenya.
**Environmental impacts of cage culture in Lake Victoria, Kenya.**

ABSTRACT Cage farming in most East African countries seems to be a new technology and this came about as a result of the decline in catches of fish around Lake Victoria basin and growing demand for protein from fish which has ultimately resulted into strengthening strategies of boosting aquaculture productions so as to fill the growing gap of productions from capture fisheries. An experimental cage culture study was conducted at Anyanga beach, Lake Victoria ,Kenya from January to September 2018, to investigate the impacts of cage culture to the environment. Three locations along the cages were identified for sampling, near the shoreline, at the intermediate and at the offshore. Samples were then analyzed for nutrients, phytoplankton and macro invertebrates. A notable increase in nutrient concentration was observed especially Phosphorous and Nitrogenous compounds after the set of cages among the stations. However Dissolved Oxygen, pH, Temperature, and water transparency showed no major changes and were within the recommended ranges. Cyanophytes an indicator of inorganic pollution dominated before and after the set of cages, an increase in phytoplankton numerical abundance was observed after stocking of fish in cages. In addition there was an increase in the invertebrate community especially gastropods. In

conclusion we found no consistent environmental change caused by cage culture, and therefore it can be allowed in Lake Victoria, Kenyan part, with close monitoring of its impacts. **Keywords:** Cage farming, Phytoplankton, Macro invertebrates, Nutrients

# P

**Evance Pakuwal**[1], Salan Ghaju[2], Wilson CJ Chung[1,2] and Xiaozhen Mou[1], [1]Kent State University, Department of Biological Sciences, Kent, OH, USA, [2]Kent State University, Department of Biomedical Sciences, Kent, OH, USA. **The Effect of Long-Term Exposure to Sublethal Dosage of Cyanotoxins on Gut Microbial Communities.**

Microcystins (MCs) are commonly produced during cyanobacterial harmful algal blooms (CyanoHABs). MC contamination in surface water is not only a major environmental problem, but also threaten the safe use of drinking water for human. MCs are categorized as liver toxins, however, their toxic effects have been related to gut dysbiosis. However, existing studies have mostly focused on acute exposure to MCs at high concentrations, and the extent of gut environment deterioration after long-term sublethal exposure to MCs is unclear. We hypothesized that long-term sublethal exposures to the MCs will lead to a gradual shift of gut microbial community, which poses a chronical central stress response in mice. In a pilot experiment, we collected fecal samples from mice (C57/BL6) that had been fed intragastrically with water (control), MC-LR (a model MC compound, 50 μg/kg bw), or MC-LR (500 μg/kg bw) for 21 days. After DNA extraction, and PCR amplification, 16S rRNA gene sequencing was performed to examine microbial profiles of the gut microbiome. Preliminary findings suggest that there are changes in the microbial diversity of the treatment groups compared to the control group. The findings suggest that the damage caused by exposure to low dosage of MC on a regular basis could cause issue not limited to just liver but also gut microbiome. As the dosage administered in this study were below the limit suggested by current drinking water guidelines, the findings could be significant on evaluating the current drinking water standards.

**Yanqun Pan**[1], Geneviève Potvin[2], Simon Bélanger[1,3] and Yannick Huot[2], [1]Arctus INC., Rimouski, QC, Canada, [2]Université de Sherbrooke, Sherbrooke, QC, Canada, [3]Université du Québec à Rimouski, Rimouski, QC, Canada. **GAAC: A Tool for moderate to high spatial resolution imagery over inland and coastal waters.**

Atmospheric correction (AC) over inland waters is extremely challenging in small-scale aquatic remote sensing (lakes, rivers, streams). This is due to the complex optical properties of all three components of the problem: the sky glint, the surrounding environment or so-called adjacency effects (AE), and the water itself. Rough assumptions, typically used for ocean color data processing, are not enough to separate the signal from these three components. None of the current methods of AC succeeds in removing the AE reflectance due to complex geometries and unknown aerosol type and concentration. The traditional AC method that retrieves aerosol without considering AE or treats AE separately systematically fails for small lakes, with remote sensing reflectance retrieval errors greater than 100% in the visible bands. Here we present a novel AC algorithm, GAAC (Genetic Algorithm-based Atmospheric Correction) able to retrieve simultaneous: AE reflectance, sun glint, aerosols optical thickness and types, and the water remote sensing reflectance. The results of the validation and intercomparison show that the proposed algorithm has improved significantly (>50% improvement over the mostte popular algorithms, e.g. ACOLITE) the water reflectance retrieval over complex lake environments for various water types. In addition, a case study shows that adjacency effect correction can also improve the accuracy of satellite-derived bathymetry.

**Andrew Parnas** and Dr. John Farrell, State University of New York College of Environmental Science and Forestry, Syracuse, NY, USA. **Effects of Invasive Cattail on Zooplankton Community Composition in Littoral Wetlands.**

Hybrid cattail (*Typha x glauca*) is an invasive emergent macrophyte that is associated with increased litter cover and reduced submersed aquatic vegetation (SAV) species richness in littoral wetlands, which may affect zooplankton community composition. Changes to littoral wetland zooplankton communities could impact other species that rely on zooplankton as a food resource. We expected that 1) zooplankton species richness and abundance would be lower in habitat dominated by *T. x glauca* than in habitat dominated by native bulrush (*Schoenoplectus tabernaemontani*), and 2) the relative abundances of large copepoda and cladocera would be lower in *T. x glauca* habitat. Fieldwork was conducted in a littoral wetland on the St. Lawrence River, with distinct zones dominated by either *S. tabernaemontani* or *T. x glauca*. Vegetation was surveyed at six plots within each zone, and zooplankton were collected from each plot and identified to species level. Statistical analysis shows that zooplankton species richness and abundance were significantly lower in plots with low SAV species richness and high *T. x glauca* litter coverage. The relative abundance of immature copepods was also significantly lower in *T. x glauca* habitat compared to *S. tabernaemontani* habitat, but no significant difference in cladocera relative abundance was found.

**James Pauer**[1], Wilson Melendez[2], Lisa Lowe[3], Tom Hollenhorst[1], Terri Jicha[1], Aabir Banerji[1], Anna Peterson[4] and Kansas Keeton[5], [1]USEPA/ORD, Duluth, MN, USA, [2]GDIT, Chicago, IL, USA, [3]NCSU, Raleigh, NC, USA, [4]ORAU, National Student Services Contract, Duluth, MN, USA, [5]ORISE Research Participant, Duluth, MN, USA. **Assessing Cyanobacteria in the Great Lakes: The need for transparent and maintainable models.**

Cyanobacteria blooms are a major concern in the Great Lakes, especially in Western Lake Erie where these blooms have severely impaired recreational and drinking water usage. Cyanobacteria have also been detected, surprisingly, in the colder oligotrophic Lake Superior. Observational data are the best way to assess the current cyanobacterial conditions. However, due to the sporadic nature of the blooms, a wealth of samples would be necessary to accurately assess the lakes. Process-based models can be useful tools to fill in the data gaps and address the impacts of climate and landscape changes on the frequency and extent of cyanobacteria blooms. However, we do not have a complete understanding or the necessary data to quantify many of the processes. Yet, these limitations have not deterred modelers from making predictions on systems frequented by blooms. Due to the "black-box" nature of complex models, it is not always clear how the results were calculated, or how much faith to put in the predictions, and how they could be extended to areas rarely experiencing blooms. Here we will discuss an approach to modeling cyanobacteria in the Great Lakes, explain the need for transparency, and demonstrate how collaborative efforts between modelers and ecologists can ensure improved and widely accepted results. The models will be formulated and applied for two contrasting systems: Lake Erie and Lake Superior.

**Pranesh Paul**[1], Ramesh Rudra[1], Pradeep Goel[2] and Prasad Daggupati[1], [1]University of Guelph, Guelph, ON, Canada, [2]Ontario Ministry of the Environment, Conservation and Parks, Etobicoke, ON, Canada. **Benchmarking Technique: Study for Generating Water Quality Constituents in Data Limited Region.**

Predictions in ungauged or data scarce basins are one of the major challenges in hydrology. This study considers two cases of data scarcity on the way to perform regionalization study and to develop a benchmarking combination to generate Sediment and Phosphorous time series in data-zero condition. In the process, 290 sub-basins of Lake Erie basin are considered. Soil and Water Assessment Tool (SWAT) is set up in the process. Further, the most similar sub-basins are identified through clustering test. Physical and meteorological characteristics of the sub-basins are used in the process. Then, parameters of calibrated and validated SWAT set up of the most similar sub-basins are shifted to the respective reference sub-basins (for the common period). Applying benchmarking technique, the regionalization approach is assessed, and it

proves to be satisfactory. Then, sediment and phosphorous time series are generated for data-zero condition using a benchmarking combination. The generated time series show better alignment with the gauged data. However, it is still tough to identify a single best combination of benchmarking condition to generate the most perfect time series in an ungauged basin in data-zero condition. However, irrespective of the quality, the generated time series may be used for performing future modelling. The detailed results of this study will be presented in the conference. **Keywords:** Regionalization, Similarity index, Cluster analysis, Benchmarking, Data-zero condition

**Christopher John Payne** and Patricia Lynn Corcoran, Western University, London, ON, Canada.
**Microplastic Pollution in Water and Air of an Agricultural Region in the Thames River Watershed.**

Atmospheric and river water samples have been shown to contain microplastic particles, especially in urban locations. Although agricultural land use areas have been investigated for microplastic levels in soils, few studies focus on air and river water in agricultural regions. We collected passive and bulk air samples biweekly for 6 months to determine microplastic types and abundances at an agricultural site – the Environmental Sciences Western Field Station. Thames River water was sampled 17 km northeast of the field station just prior to, during, or immediately following precipitation events over the same 6 months to determine correlations between matrix types, if any. The abundances of microplastics will be measured against river discharge data to determine microplastic load during precipitation events, whereas for air samples, the results will be compared with average precipitation amounts and wind speed. The overall findings from the Thames River watershed will eventually be compared with air and water results from an urban and a rural location to discover the relative input of microplastics to the Great Lakes from different land use areas.

**Douglas R Pearsall**[1], David Karpovich[2], Sherry L Martin[3] and Autumn McGowan[1], [1]The Nature Conservancy, Lansing, MI, USA, [2]Saginaw Valley State Univ., University Center, MI, USA, [3]US Geological Survey, Lansing, MI, USA. **Funding and governance models for watershed-scale water quality monitoring: Exploring options for Saginaw Bay.**

Since 2017, members of the Saginaw Bay Monitoring Consortium (SBMC) have collaborated to establish more comprehensive and continuous water quality monitoring to inform management decisions and recovery efforts affecting Saginaw Bay and its tributaries, and to provide timely information to diverse audiences. We have engaged interested parties to agree on priority water quality parameters, develop a plan for more comprehensive and continuous monitoring, optimize tributary monitoring locations, expand monitoring in the bay, develop a public-facing data and information portal, and have obtained funding to support the effort through 2025. Now, we are exploring various models of governance and sustainable funding to enable adaptive management of the monitoring program, ecosystem modeling and tracking of progress towards water quality goals. We will present examples of governance and funding from other large-scale, watershed-based efforts and describe and seek feedback on potential models for the SBMC.

**Dale Pebesma**, Donald Jackson and Benjamin Gilbert, University of Toronto, Toronto, ON, Canada.
**Temporal dynamics of benthic macroinvertebrate communities in an urbanized Lake Ontario tributary.**

Exploring the temporal changes to Great Lakes tributaries is essential to understand cumulative downstream impacts and to inform management decisions. Using a 20-year monitoring dataset of benthic macroinvertebrates in the Credit River watershed, Ontario, we examine how stream characteristics and water chemistry have impacted diversity in this Lake Ontario tributary. Using this classic biomonitoring group of taxa, we investigate patterns of long-term change to help inform cumulative downstream impacts. We implement a mixed-modelling approach to assess these patterns, as well as highlighting key differences among widely-used benthos sampling protocols in Ontario (CABIN and OBBN). We find decreases in

Shannon diversity and sensitive taxa, with increases in tolerant taxa, despite no overall change in richness through time. Moreover, diversity changes are highly dependent upon both stream order and location of streams in the watershed. We find notable differences among sampling protocols used, urging caution in interpreting timeseries incorporating multiple sampling methods without statistical correction. Overall, our results demonstrate long-term decline in diversity in this watershed and highlight where management may be most effective upstream to mitigate downstream effects on the lake community.

**Paige J. Penningroth**[1], Bridget R. Thornburg[1], Matthew J. Hudson[1], Matthew J. Cooper[2] and Peter S. Levi[1], [1]Mary Griggs Burke Center for Freshwater Innovation, Northland College, Ashland, WI, USA, [2]Institute for Great Lakes Research, Central Michigan University, Mount Pleasant, MI, USA. **Synergistic influence of land use and storms on total phosphorus load in Lake Superior tributaries.**

Total phosphorus (TP) loads from Great Lakes tributaries are influenced by spatial variation in watershed land use and size. In addition, temporal variation in stream discharge, especially high flows during storm events, flush a large fraction of the annual load downstream in a short period. Tributaries to Chequamegon Bay provide a unique location to assess the interactive effects of spatial and temporal variation of TP load as it relates to gradients in watershed land use and storm-driven run-off. We assessed annual TP loads from several tributaries draining into Lake Superior from forested and mixed agricultural-urban watersheds. We also analyzed the proportion of the TP load that was bioavailable (i.e., soluble reactive phosphorus; SRP). Our initial analysis suggests that the majority of TP load in these streams occurs during short temporal periods and increases in load are exacerbated in human-dominated landscapes. In 2018, a major storm event elevated annual TP load 2- to 6-times higher than the five-year median in the developed watersheds, whereas we did not observe a large deviation from the median in a forested watershed. Given the predominance of clay soils in the Chequamegon Bay region, only a small fraction of phosphorus was exported as SRP. The synergistic increase in TP load during discrete storm events from watersheds with human-dominated land use demonstrates the need to manage nutrients in both space and time.

**Brittany Perrotta**[1], David Walters[2], Amy M Marcarelli[3], Gordon Paterson[3] and Karen Kidd[1], [1]McMaster University, Hamilton, ON, Canada, [2]USGS, Columbia Environmental Research Center, Columbia, MO, USA, [3]Michigan Technological University, Houghton, MI, USA. **Shifts in insect and riparian spider microbiome across the aquatic-riparian interface in a lake with elevated copper.**

Microbial communities living in or on a host comprise an organism's microbiome and play diverse and critical roles in host organism biology. Copper is a well-known antimicrobial agent, and while an essential micronutrient, excessive exposure can alter a host organism's microbiome. Some aquatic insects have extended life stages in the benthos where they may utilize copper contaminated sediments before undergoing metamorphosis and emerging as terrestrial adults. Riparian predators such as tetragnathid and araneid spiders are useful bioindicators of aquatic ecosystem condition because they specialize in the predation of adult aquatic insects. Torch Lake, an Area of Concern in Michigan, USA, has an extensive history of copper mining and, as a result, has elevated copper concentrations in the sediments. Here, we demonstrate a significant alteration of the larval insect, adult insect, and spider microbiome community in organisms living in and adjacent to Torch Lake. The microbial community composition of whole benthic and emerged insects and spiders collected from Torch Lake were significantly different than the same taxa collected from the reference lake. Our results demonstrate legacy impacts of historical mining activities on the host microbiomes of aquatic-riparian food webs, which may impact other processes as insects and spiders provide critical subsidies of energy and material fluxes at the land-water interface.

Tia Jenkins[1], **Bhaleka D. Persaud**[1], Win Cowger[2], Kathy Szigeti[3], Dominique G. Roche[4], Erin Clary[5], Stephanie Slowinski[1], Benjamin Lei[1], Amila Abeynayaka[6], Ebenezer S. Nyadjro[7], Thomas Maes[8], Leah

Thornton Hampton[9], Melanie Bergmann[10], Julian Aherne[11], Sherri A. Mason[12], John F. Honek[1], Fereidoun Rezanezhad[13], Amy L. Lusher[14], Andy M. Booth[15], Rodney D. L. Smith[1] and Philippe Van Cappellen[13], [1]University of Waterloo, Waterloo, ON, Canada, [2]Moore Institute for Plastic Pollution Research, Long Beach, CA, USA, [3]Davis Centre Library, University of Waterloo, Waterloo, ON, Canada, [4]Department of Biology, Carleton University, Ottawa, ON, Canada, [5]Digital Research Alliance of Canada,, Ottawa, ON, Canada, [6]Institute for Global Environment Strategies (IGES),, Kanagawa, Japan, [7]National Oceanic and Atmospheric Administration (NOAA) & National Centers for Environmental Information (NCEI), Starkville, MA, USA, [8]GRID-Arendal, Arendal, Norway, [9]Southern California Coastal Water Research Project (SCCWRP), Costa Mesa, CA, USA, [10]12Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung, Bremerhaven, Germany, [11]Trent University, Peterborough, ON, Canada, [12]14The Behrend College, Pennsylvania State University,, Erie, PA, USA, [13]Ecohydrology Research Group, University of Waterloo, Waterloo, ON, Canada, [14]Norwegian Institute for Water Research (NIVA), Oslo, Norway, [15]SINTEF Ocean AS, Trondheim, Norway. **Data sharing practices and best data management for microplastics pollution.**

In recent years, concerns over microplastic (MP) pollution have increased, leading to an exponential growth in MP research. To support science-based policies, it is essential that the data associated with this research are findable, accessible, interoperable, and reusable. We present a bibliographic analysis of MP research data to determine their findability and accessibility. A subset of 785 MP peer-reviewed articles were randomly selected from 6608 total publications published between 2013 and 2021 for the bibliographic analysis. Of the 785 articles analyzed, only 28.5% had a data sharing statement. Of those with a data sharing statement, 38.8% shared the data in the supplementary material, and only 13.8% shared the data in a digital repository. In addition, we found that among 279 MP datasets available in open access repositories, only 15.4% and 18.2% had adequate metadata to determine the sampling location and media type, respectively. Based on the insights gained from this study, we offer five recommendations to the MP research community to support data sharing and data management practices. These include: use available metadata standards/practices to describe data, use a trusted repository, and link datasets to publications. Read more at https://doi.org/10.3389/fenvs.2022.912107.

**Fritz Petersen**[1], Timothy Hoellein[1], Bailey Schwenk[1], Elizabeth Kazmierczak[1], Richard Lammers[2], Emily Lever[2], Jacob Haney[3], Chelsea Rochman[3], Wilfred Wollheim[2], Xia Zhu[3] and Shan Zuidema[2], [1]Loyola University Chicago, Chicago, IL, USA, [2]University of New Hampshire, Durham, NH, USA, [3]University of Toronto Scarborough, Toronto, ON, Canada. **Storm Induced Microplastic Flux in an Urban Watershed.**

Plastic pollution is a global ecological concern, and rivers are a key source of plastic to oceans. Advancements in watershed-scale models of plastic fluxes, including those with the goal of estimating the contribution of plastics to the global carbon cycle, requires direct measurements of plastics during different flow conditions. However, few studies have measured microplastics before, during, and after storms and at high sampling frequency. We used autosamplers to sample microplastics before, during, and after 3 separate storms at 3 sites in an urban watershed. We also measured macroplastics and microplastics at the 3 sites before and after storm events. We predict that the rising limb of the hydrograph will show the greatest increase in water column microplastics. We expect microplastic flux will be positively correlated to macroplastic flux and relative storm size. These data will improve our understanding of stormwater microplastic movement and will directly inform improved ecosystem budgets and models of plastic litter at the reach- and watershed scales.

**Sarah Peterson**[1] and Chin H Wu[2], [1]University of Wisconsin - Madison, Madison, WI, USA, [2]University of Wisconsin-Madison, Madison, WI, USA. **Shoreline change near coastal structures under water level fluctuations and varying wave climate.**

Shoreline changes are extremely important in terms of economic, environmental, and societal impacts in the Laurentian Great Lakes. In this talk, we aim to address the knowledge gap on how shorelines change near coastal structures under fluctuating water levels and varying wave climates. Specifically, we characterize shoreline changes along Madeline Island, in Lake Superior, as an example. There are several findings. First, qualitative analysis of aerial and oblique imagery reveal how shoreline changes near structures differ during low, mean, and high-water level periods. Second, quantitative shoreline analysis delineates indirect and direct hazards near coastal structures. Third, wave climate analysis of the island depicts the role of spatially-varying wave climates on shoreline changes near and away from coastal structures. Overall, results of the study can be used to assess coastal protection options, improve coastal management practices, and guide decision-making in the Great Lakes.

**Sally Petrella**, Friends of the Rouge, Plymouth, MI, USA. **Rouge River Citizen Science Programs Engage Residents in filling in Data Gaps to Guide River Restoration.**

Restoring an urban watershed is a complex process best guided by robust data collection and adaptive management yet monitoring of restoration projects is often under prioritized and underfunded. The Rouge River watershed in southeast Michigan, an International Joint Commission designated Great Lakes Area of Concern with impaired waters, has been the focus of a massive cleanup since the 1970s. Federal funding through the Rouge River National Wet Weather Demonstration Project supported the cleanup and a strong monitoring and evaluation plan through 2014. Following that, funding sources have focused on "boots on the ground" projects that include little to no monitoring requirements to determine if the project is meeting its intended goal. To fill this gap, the non-profit watershed organization Friends of the Rouge has been training residents to collect data on biological indicator species. Over the past twenty-three years, these citizen scientists have been collecting data comparable to professionals at far lower cost with the added benefit of empowering regular residents to study and get to know the watershed and become actively involved in restoring the river. Focusing on living things such as bugs, frogs, toads and fish has proven an engaging and activity that attracts dedicated citizen scientists that participate year after year, bring their family and friends and become some of the best advocates for the river who understand how their actions impact water quality.

**Nhu Hoang Van Pham**[1], Cary D. Troy[2] and David Cannon[3], [1]Purdue University, West Lafayette, IN, USA, [2]Purdue University-West Lafayette, West Lafayette, IN, USA, [3]Cooperative Institute for Great Lakes Research, University of Michigan, Ann Arbor, MI, USA. **Accounting for Wind-Waves Improves Shallow-Water Mixing Predictions in Large Lakes.**

The purpose of this study is to analyze turbulent mixing in shallow water regions of large lakes under wind-driven condition and create a framework to improve the parameterization of the surface boundary layer and account for the effects of wind waves in shallow-water mixing. Nearshore shallow-water mixing in large lakes have not been extensively quantified due to its complexity: the area behaves neither as shallow-water of the oceans due to the absence of tides, nor that of small lakes where wind might induce complete mixing, which can be challenging to parametrize in 1-D mixing models when extensive field measurements are limited. In this presentation, observations on turbulent mixing under low-energy, weakly-stratified condition were analyzed using measurements collected from shallow water sites in Lake Michigan (USA) with moored velocimeters and thermistors, microstructure profiles, and open-sourced meteorological data. Despite a dominant contribution of wind in driving turbulence, model predictions were inconsistently overestimating the mixing parameters. As waves are typically not factored in the computation for the interim of the water column, we argued that proportioning total wind stress into turbulence-induced and wave-induced stresses could effectively improve mixing prediction in shallow-water. Understanding the different processes determining nearshore mixing is important because of its coupling relationship with biological, chemical, and physical processes and biogeochemical problems such as invasive benthic filter-feeders.

Allegra Cangelosi, **Hannah Phillips**, Ivor Knight and Matthew Gruwell, Penn State Behrend, Erie, PA, USA. **A Straw Protocol for Early Detection of Ballast-Mediated Target AIS in Great Lakes Harbors using PCR.**

Harbor monitoring for rare species in Great Lakes harbors is expensive, demanding, and time-consuming using conventional methods. Yet early detection of newly established AIS can be the only way to prevent their further spread from the lower Great Lakes to Lake Superior in Laker ship ballast transfers, which are still untreated. Routine surveillance for target species eDNA using novel PCR tools can deliver vital information about potential reproducing populations in harbors of ballast uptake. Though PCR does not discern live/dead status of organisms associated with detected eDNA, live status can be inferred from repeated eDNA positive outcomes from sampling of uptake locations over time, especially in the context of known hydrologic patterns. More expensive and time-consuming conventional sampling could then be targeted to locations with positive eDNA signals for confirmation purposes only. We developed and applied criteria to select a Great Lakes harbor and target organism and designed a straw repeated measures monitoring protocol adaptable to a range of hydrologic considerations.

**Morgan Leigh Piczak**[1], Steven Cooke[1] and Jonathan D. Midwood[2], [1]Carleton University, Ottawa, ON, Canada, [2]Fisheries and Oceans Canada, Burlington, ON, Canada. **Towards effective ecological restoration: Knowledge co-production with Aquatic Habitat Toronto.**

For decades, the working paradigm for ecological restoration was independent operation of knowledge generators (researchers and scientists) and knowledge users (decision makers and practitioners), resulting in a knowledge–action gap. Knowledge co-production is a collaborative process where research is conducted in a respectful and engaging manner with continuous knowledge exchange and heralded as a means of bridging the divide. Aquatic Habitat Toronto (AHT) is a unique consensus-based partnership with diverse member agencies that engage in restoration ecology and practice along the Toronto Waterfront of Lake Ontario, Canada. Benefits to AHT's consensus-based partnership include advanced notice of projects, access to diverse expertise and local knowledge, increased understanding of fish habitat, adoption of novel restoration techniques and more effective restoration and improved knowledge exchange, collectively mitigating the knowledge–action divide. Challenges of knowledge co-production facilitated by AHT include consistent agency participation and meaningful engagement, closed or exclusive networks, time commitments and limited financial resources, evolving political landscapes, stability of funding cycles and issues stemming from varying goals and relevancy. AHT embraces an approach that includes integrated planning with multi-jurisdictional support with diverse partners at a tractable scale and we argue that this should be the standard model of aquatic ecosystem management.

**Rhiannon Pinkerton** and Christopher Wellen, Toronto Metropolitan University, Toronto, ON, Canada. **Predicting Soil Test Phosphorus Concentrations across Ontario to Aid in Management Strategies for The Great Lakes.**

Algae blooms from excessive nutrient pollution negatively affect water quality in the Great Lakes. Phosphorus is an essential nutrient for optimal plant growth however, high amounts of phosphorus levels in the soil are considered a potential source of phosphorus loss when there are favourable hydrological conditions. This may lead to surface and subsurface runoff into bodies of nearby water. Understanding where phosphorus is among soils in Southern Ontario is important because it could be the source of phosphorus nutrient pollution into the Great Lakes. Currently, estimates of soil test phosphorus are only available at a county scale in Ontario (around 3400). The goal of this research is to fill this gap in knowledge by using an existing database of more than 4000 field scale soil phosphorus observations and other public databases on Ontario physical soil properties to develop a prediction model using machine learning. The resulting model will be used to map soil test phosphorus levels across Southern Ontario and help predict downstream effects on the Great Lakes. These findings will result in a better understanding of the factors most influential for fine scale phosphorus variability. This will help guide future modelling and management.

**Basia Pioro**[1], Catherine M Febria[2] and John H. Hartig[3], [1]University of Windsor, Windsor, ON, Canada, [2]Healthy Headwaters Lab, University of Windsor, Windsor, ON, Canada, [3]University of Windsor, Great Lakes Institute for Environmental Research, Windsor, ON, Canada. **Advancing the Ecosystem Approach as an integrated science-management framework.**

The Ecosystem Approach has long offered a collaborative framework for stewarding, governing and researching the health of the Laurentian Great Lakes and other large ecosystems globally. 2022 marked the 50th anniversary of the Canada-U.S. Great Lakes Water Quality Agreement. This landmark agreement between Canada and the United States is grounded in many sound principles, including ecosystem-based management. Over this period, we witnessed many successes and yet many challenges remain. Here we present a Great Lakes focused project to help accelerate science, management and relationships that will usher in new perspectives and re-frame ways of bringing together knowledges and of mobilizing them into action. Informed by a global conference and synthesis workshops held in August 2022, and a series of workshops through 2023, an emergent theme has been the necessity for boundary organizations and actors who are essential in bridging science, policy and practice. A more holistic and systems-based approach has the potential offer more inclusive, sustainable and effective application of the Ecosystem Approach. We will highlight key findings from working groups and discuss opportunities for future engagement within the IAGLR community and beyond.

**Lindsay RC Platt**[1], Hilary Dugan[1], B Steele[2], Matt Ross[2], Kaitlin L Reinl[3] and Bob Sterner[4], [1]Center for Limnology, University of Wisconsin-Madison, Madison, WI, USA, [2]Ecosystem Science and Sustainability, Colorado State University, Fort Collins, CO, USA, [3]Lake Superior National Estuarine Research Reserve, University of Wisconsin-Madison, Superior, WI, USA, [4]Large Lakes Observatory and Department of Biology, University of Minnesota Duluth, Duluth, MN, USA. **Remote Sensing Plumes and Blooms in Lake Superior and Assessing Climate Drivers.**

Cyanobacterial blooms have been observed in Lake Superior, sparking national media attention. Presently, there is a lack of monitoring data that can resolve whether blooms are arising out of changing climate conditions or whether reporting has increased. To investigate bloom occurrences, we built a novel pipeline using the Harmonized Landsat Sentinel-2 (HLS) data fusion product (Claverie, et al. 2018) for western Lake Superior. The result of the pipeline is open water, sediment-plume, and algae bloom identification. We built algorithms that distinguish between sediment plumes and algae blooms using common spectral indices. Using these algorithms allows us to create a rasterized time series of presence and absence of sediment plumes and blooms. From the gridded time series product we built a model using nutrient loading, climate, and landscape characteristics to investigate climate and hydrological drivers of bloom occurrence. This approach can be used to understand how climate change may affect nearshore bloom activity in Lake Superior and to provide recommendations for land and water management strategies that might be employed to combat bloom frequency.

**James A Polidori**, Great Lakes Commission, Ann Arbor, MI, USA. **Improving water management and climate resilience through regional coordination and collaboration.**

The Great Lakes Commission (GLC) has a unique ability as an agency representing states and provinces in the Great Lakes basin to convene representatives from governmental and nongovernmental organizations. In this capacity, the GLC has served as the repository for The Great Lakes Regional Water Use Database since 1988. This standardized approach represents a collaborative regional effort to promote sustainable water management, improve data quality, and guide the future development of our water resources. The GLC has continued to carry out its role in the region by producing an annual report on Great Lakes-St. Lawrence River water withdrawals, diversions and consumptive uses and, most recently, by creating an Action Plan for a Resilient Great Lakes Basin to build and establish regional coordination around climate resilience. This Action Plan was adopted by the GLC in 2022. The Action Plan aims to share existing knowledge and resources, collaborate on developing new knowledge, and ensure diverse expertise

and resources are made available throughout the basin. This presentation will demonstrate how the Great Lakes Commission can utilize its decades of experience overseeing regional collaboration of water management to ensure the resiliency of communities, infrastructure, ecosystems, and the economy of the Great Lakes region.

**Hannah Postma**[1], Steven Cooke[1], Vivian Nguyen[1], Andrea Reid[2], Elizabeth Nyboer[2], Alexander Duncan[3], Nathan Young[4], Mike Steeves[5], Bill Mattes[6], Marc Gaden[7], Gary Pritchard[8] and Jessica Barber[9], [1]Carleton University, Ottawa, ON, Canada, [2]Centre for Indigenous Fisheries, University of British Columbia, Vancouver, BC, Canada, [3]University of British Columbia, Vancouver, BC, Canada, [4]University of Ottawa, Ottawa, ON, Canada, [5]Department of Fisheries and Oceans Canada, Sault Ste. Marie, ON, Canada, [6]Great Lakes Indian Fish and Wildlife Commission, Odanah, WI, USA, [7]Great Lakes Fishery Commission, Ann Arbor, MI, USA, [8]4 Directions Conservation Consulting, Ottawa, ON, Canada, [9]U.S. Fish and Wildlife Service, Marquette, MI, USA. **Lessons learned towards the shared responsibility of safeguarding Great Lakes fisheries.**

Across the Great Lakes basin, Indigenous and non-Indigenous agencies strive to protect and sustain healthy fish and water systems. However, the cumulative impacts of climate change and other human disturbances combined with historical and ongoing instances of environmental injustices towards Indigenous Peoples call for a shift away from current management paradigms towards structures that center meaningful collaboration and Indigenous leadership. Here, we present early outcomes from interviews with Indigenous and non-Indigenous fishery professionals who work with and for Indigenous agencies on the Laurentian Great Lakes. We assess experiences and perspectives from within these agencies to better understand what is needed to build meaningful co-management relationships among Indigenous and non-Indigenous agencies committed to safeguarding Great Lakes fisheries. We hope this research can help ready current and future fishery professionals to engage in just and effective approaches to fisheries decision-making.

**Logan Potter**[1], Brant Fisher[2], Tomas O Hook[1], Jacques Rinchard[3], Benjamin Szczygiel[1], Michelle Benavidez Westrich[4] and Jacob Hosen[1], [1]Purdue University, West Lafayette, IN, USA, [2]Indiana DNR, Edinburgh, IN, USA, [3]SUNY Brockport, Brockport, NY, USA, [4]Indiana DNR, Bloomington, IN, USA. **Fatty acid differences amongst different populations of river mussels.**

There is increasing recognition that riverine mussels are important drivers and indicators of freshwater quality and ecosystem integrity. Due to their ability to accumulate various contaminants from pollution, mussels have long been known as indicator species. Yet, indicators of freshwater mussel health and food source are not well studied. Fatty acid profiles have been shown to indicate food source and health of fish among other species, but data does not yet exist to facilitate reliable interpretation of mussel fatty acid profiles. Here, we studied fatty acid profiles of riverine Wabash Pigtoe (*Fusconaia flava*) mussels at six locations upstream and downstream of 3 reservoirs located across Indiana. We found that fatty acid profiles were very strongly linked to individual sites. Fatty acids C17:0, C20:0, C17:0, C15:0, and C16:1n-9 drove most of the differences between sites. Of these fatty acids, C17:0 was significantly higher in mussels upstream of reservoirs compared to those downstream of reservoirs across all sites. Preliminary results have revealed that there is indeed a difference between fatty acid levels as well as potential indicators that these differences are being driven by environmental factors. Given these differences, fatty acid profiles are a promising avenue for elucidating indices of freshwater mussel health.

**Kelsey Prihoda**[1], Aude Lochet[2], Natalie Chin[3], Mark Burrows[4] and Rachel Pryor[5], [1]Sea Grant College Program, University of Minnesota, Duluth, MN, USA, [2]Lake Champlain Sea Grant, State University of New York Plattsburgh, Plattsburgh, NY, USA, [3]Wisconsin Sea Grant, Superior, WI, USA, [4]Great Lakes Regional Office, International Joint Commission, Windsor, ON, Canada, [5]Office of Response and Restoration,

National Oceanic and Atmospheric Administration, Cleveland, OH, USA. **How HazMaTON is working to help advance oil spill science in the Laurentian Great Lakes.**

The Hazardous Material Transport Outreach Network, or HazMaTON, is a binational collaborative of specialists from the Great Lakes, Lake Champlain, Hudson River, and St. Lawrence River regions focused on reducing risks associated with multiple transportation modes of oil and other hazardous materials. The group was formed in 2014 as a regional extension program within the Great Lakes Sea Grant Network, and membership has expanded since that time in an effort to better understand the social, economic, and environmental impacts of hazardous material movement throughout the Laurentian Great Lakes. One of HazMaTON's goals is to increase knowledge of the potential ecological impacts of hazardous materials spills in freshwater environments. HazMaTON also aims to expand awareness of emergency response planning efforts in the Laurentian Great Lakes region. This presentation will detail HazMaTON's strategies for achieving this goal through increasing interconnectedness of our target audience, effective science communication, determining public awareness of emergency response planning and management, and providing targeted outreach activities.

**Cameron Proctor**, Deqa Farow and Rebecca Lebel, University of Windsor, Windsor, ON, Canada. **Crop root imaging at scale: Evidence from lab biosolid experiments.**

The development of agricultural best management practices is a scientific exercise that evaluates specific farm practices by several economic and environmental markers including plant yields, soil health, and vigor of aboveground plant tissues. Typically plant roots are excluded from such assessments, despite that fact that the "hidden half" (i.e., roots) play a stronger role in nutrient uptake and there are several mechanisms through which root sink strength regulates photosynthesis and limits growth. Here we present progress to date on the development of inexpensive hardware and software solutions for the collection and processing of root imagery applied to field scale monitoring of cropping farms. In particular, the influence of biosolids on the rooting systems of soybeans grown in Burford Loam soil in a climate controlled greenhouse showed unique rooting architectures compared to controls. Total root length of the root system and the average number of roots tips declined from 7,165mm to 5,982mm ~2,977 to 2,237 in the biosolid treatment, albeit the root diameter increased from 2.65mm to 2.89mm. Biosolid effects different by species with wheat and soybeans showing declines in the above to belowground biomass ratio, while alfalfa showed a two-fold increase.

**Aaron Pruitt**, Wisconsin Department of Natural Resources, Madison, WI, USA. **From dry streams to flooded fields: Managing groundwater/surface water interactions in a changing climate.**

In the late 2000's to early 2010's, parts of Wisconsin received less annual precipitation than they had received in decades. In some cases, annual precipitation totals were nearly as low as the Dust Bowl era. However, the past decade has been a time of abnormally abundant rainfall, with some of the wettest years on record happening within a few short years. During this upswing in precipitation totals, surface water features as large as Lake Michigan and Lake Superior have also shown an upswing, in some cases increasing 4 to 6 feet over that time. While these increases in water levels are significant on the scale of the Great Lakes Basin, the changes are even more apparent at smaller spatial scales. Headwater streams and inland lakes that are at or near record highs today were nearly dry less than ten years prior. The WDNR's Water Use Section is tasked with the management and regulation of water quantity including groundwater-dependent surface water resources. Wisconsin's recent efforts in developing and communicating groundwater management recommendations that reduce harm to Wisconsin's waters while being adaptive to climatological shifts is an ongoing struggle. This presentation describes our approach to these challenges.

**Nicholas Puopolo**[1] and Genevieve Ali[2], [1]University of Guelph, Markham, ON, Canada, [2]University of Guelph, Guelph, ON, Canada. **Spatiotemporal Variability of Climatic, Extreme Weather, and Agroclimatic Indices in Three Great Lakes Basins.**

Studying how climate change has impacted areas containing predominantly agricultural land is critical to optimizing current agricultural management practices. Stable versus shifting trends in growing season length, precipitation metrics, and dry and warm spells can notably provide important information to devise adaptation strategies. To date, very few studies have resorted to fine-scale climate data to evaluate agroclimatic trends across large portions of the Great Lakes Region, which is the goal of the present study. The focus is on an area that spans the Lake Ontario, Lake Erie, and Lake Huron basins. A fine-scale (1 km × 1 km) dataset, DAYMET, containing daily precipitation and temperature data from 1980-2021, was used to compute climatic (e.g., annual precipitation), extreme weather (e.g., warm spell), and agroclimatic (e.g., growing season length) indices and evaluate their variability. Preliminary analyses reveal average growing season length is increasing across several subregions in the study area. Ongoing analyses of precipitation, warm spell, and dry spell indices focus on the timing and magnitude of the observed changes, which will prove instrumental in determining how much adaptation is necessary related to planting and harvesting activities.

# Q

John F. Bratton[1], Karen Kidd[2], Rebecca Rooney[3], Chelsea Rochman[4], Eden Hataley[4], Austin Baldwin[5], Carl Platz[6], Carlie Herring[7], François Houde[8], Dale Hoff[9], **Samir Qadir**[10] and Lizhu Wang[11], [1]LimnoTech, Ann Arbor, MI, USA, [2]McMaster University, Hamilton, ON, Canada, [3]University of Waterloo, Waterloo, ON, Canada, [4]University of Toronto Scarborough, Toronto, ON, Canada, [5]USGS Idaho Water Science Center, Boise, ID, USA, [6]U.S. Army Corps of Engineers, Grand Haven, MI, USA, [7]NOAA, Silver Spring, MD, USA, [8]Ministère de l'Environnement et de la Lutte contre les changements climatiques, de la Faune et des Parcs, Québec, QC, Canada, [9]U.S. EPA, Great Lakes Toxicology and Ecology Division, Duluth, MN, USA, [10]Potomac-Hudson Engineering (PHE), Rockville, MD, USA, [11]GLRO, International Joint Commission, Windsor, ON, Canada. **Monitoring and risk assessment of Great Lakes microplastics: An International Joint Commission initiative.**

Microplastics are found across the Great Lakes and their watersheds – including in sediments, water, and biota – and their ubiquity raises concerns for organism health. Given the diverse organizations with microplastics programs and interests, it is timely to develop a standardized framework for their monitoring in different media and to assess the risk of these contaminants in the Great Lakes basin. The International Joint Commission recently initiated a project to collate the latest knowledge on microplastics in environmental media and biota of the Great Lakes, including their toxicity to freshwater and riparian species of relevance to this region. In addition, this project will develop recommendations for a basin-specific monitoring program with standardized approaches that can be used to understand temporal trends and biotic exposures. Finally, a risk assessment and management framework with thresholds will be developed for microplastics and an initial quantitative risk assessment will be conducted to understand potential risks to aquatic and riparian food webs today. Additional goals of this effort are to make recommendations on the use of plastics as a sub-indicator under the Great Lakes Water Quality Agreement and to inform policy and mitigation efforts. This presentation will describe the approaches to be used, timelines and products of the project, and preliminary results of the synthesis of monitoring approaches and data available in the Great Lakes basin.

**Connor Quiroz**, California State University, Monterey Bay, Seaside, CA, USA. **Causing a Stir in Northern Pitcher Plants (*Sarracenia Purpurea*).**

The diverse bacterial community in the liquid sub-habitat of the *Sarracenia purpurea* plant allows us to better study the microbial responses to press (long-term) disturbances and pulse (short-term) disturbances. We randomly selected 12 pitchers at Barney's Lake, Beaver Island, MI, and applied the following treatments: a press disturbance with a $CuSO_4$ application in the leaf cavity, a pulse disturbance with a heated mixing of the pitcher fluid, and a control group that was left undisturbed. Microbial communities were measured before and after the disturbances using DNA extraction, PCR to amplify the v4 region of the 16s rRNA and DNA sequencing. We hypothesize that during the pulse disturbance, there will be a steep drop in the bacteria present with high resilience while during the press disturbance there will be a gradual drop in the microbes present and a permanent alternative stable state will be assumed. Having an understanding of how microbes react to environmental disturbances will allow us to better assess ecological processes like increased nitrogen fixation (Gotelli & Ellison 2002), food web functions (Bradshaw & Creelman 1984) and how global warming may affect microbial communities inside pitcher plants (Hoekman 2010).

# R

**Jovana Radosavljevic**, Stephanie Slowinski, Fereidoun Rezanezhad, Mahyar Shafii and Philippe Van Cappellen, Ecohydrology Research Group, University of Waterloo, Waterloo, ON, Canada. **Salinization amplifies eutrophication symptoms in freshwater lakes.**

The rapid worldwide urban growth is linked to shifts in surface water and groundwater quality, including salinization and eutrophication of freshwater lakes receiving urban inflow. In urban areas of cold and cold-temperate climates, de-icing salts used to keep impervious areas free of ice and snow during winter are often the major driver of salinization in nearby lakes. While the ecological damages caused by nutrient enrichment and salinization of freshwater lakes are well established, thus far, their impacts on water quality have been considered separately. In this study, we analyzed over 20 years of data for a small southern Ontario lake within the Great Lakes Basin, whose watershed has experienced rapid urbanization in the past 20 years. Our results show that rising salinity may deteriorate lake health and water quality in ways usually associated with increasing external phosphorus (P) loading by extending the stratified period and, as a result, the duration of bottom water hypoxia and the internal P loading from bottom sediments. Additionally, 70-90% of the salt ions applied in the lake's watershed remain stored in soils and groundwater which can act as a future source of contamination of downstream ecosystems and threaten drinking water sources.

**Sabina Rakhimbekova**[1], Chris Power[1], Denis O'Carroll[2] and Clare E. Robinson[1], [1]Department of Civil and Environmental Engineering, Western University, London, ON, Canada, [2]University of New South Wales, Manly Vale, NSW, Australia. **Effect of climate change on the functioning of sediment traps and discharge of pollutants to large lakes.**

Nearshore groundwater systems play a key role in governing the exchange of pollutants across the land-lake continuum. Climate change induced variations in coastal water levels, wave climate, and temperature will influence the hydrological and geochemical conditions in nearshore coastal aquifers. Prior studies have shown that metal oxides (e.g. iron oxides) that form near the groundwater-lake interface in nearshore aquifers act as a sediment trap for reactive pollutants preventing their discharge to adjacent nearshore waters. However, these sediment traps may also act as legacy pollutant sources whereby trapped pollutants may be released as environmental conditions change, thereby contributing to impairment of nearshore waters. The objective of this study was to explore how climate change may affect the function of these sediment traps and their ability to retain pollutants. This presentation will cover several examples from field and laboratory investigations of how climate change induced factors may impact the functioning of the sediment trap and potential discharge of pollutants to nearshore lake waters. Overall, it is predicted that

release of trapped pollutants to coastal waters may occur if conditions in nearshore groundwater become more reducing, pH increases and/or shoreline erosion modifies the pollutant discharge pathway to nearshore waters. Study findings have broad implications for evaluating potential risks of groundwater discharge to nearshore water quality and in predicting nearshore water quality trends as the climate changes.

**Genevieve Rattray** and Donna R Kashian, Wayne State University, Detroit, MI, USA. **Addressing Environmental Leadership Through Interdisciplinary Community Engagement.**

The Great Lakes are faced with environmental challenges that threaten their sustainability. Such complex issues require strong interdisciplinary collaborations. To create successful partnerships, one must go through the process of building relationships and establishing trust, a significant step that is often mistakenly overlooked and detrimental to productive and successful outcomes. Traditional graduate programs often overlook the need to train students to engage with the community and be versed across disciplines. No one discipline, organization, or sector can move the needle on the climate crisis, but many working together can shift the narrative. Through a graduate training program, we address human-ecosystem challenges using a transdisciplinary approach to address climate hazards in partnership with local communities, businesses, industries, scientists, and policymakers, while providing a mechanism to understand and overcome contemporary societal and ecological challenges. Specifically, we outline the design and implementation of an integrated, adaptable graduate training program, with the goals of science leadership, curriculum relevance, community impact, broader applicability, establishing a career development pathway in science, technology, engineering, and mathematics (STEM) programs, to authentically engage Great Lake communities to meet environmental challenges. This interdisciplinary approach engages likely and unlikely collaborators that can help bridge the gap between science and community.

Hadis Miraly, **Roxanne Razavi** and Karin Limburg, SUNY ESF, Syracuse, NY, USA. **Project Breathless: assessing hypoxia exposure and mercury uptake in fish.**

Climate induced increases in dissolved oxygen deficits (hypoxia) are a rising issue facing freshwaters globally. Mercury is a ubiquitous pollutant and potent neurotoxicant with well-described properties of bioaccumulation and biomagnification in aquatic food webs. However, due to its redox sensitive nature, the enhanced production of methylmercury in low oxygen conditions may make mercury a useful tracer of hypoxia. To study changes in mercury exposure through time and its potential as a tracer of hypoxia, eye lenses and otoliths from Round Goby *(Neogobius melanostomus)* of Lake Erie (n = 60), the St. Lawrence River (n = 30), and the Baltic Sea (n =30) were collected. Otoliths were used to age fish, track habitat, and assess hypoxia exposure. Eye lenses and otoliths were analyzed by laser ablation inductively coupled plasma mass spectrometry (LA-ICPMS). The proportion of eye lens that relates to the corresponding otolith annulus were determined, and distances were related to corresponding mercury concentrations. Using this technique, we demonstrate a method to assess mercury concentration using eye lens chronology and map mercury and hypoxia exposure history for each individual fish. We found that eye lens mercury concentrations changed as fish aged. Eye lenses represent a continuous record of lifetime mercury exposure and hold promise for quantifying individual exposure to environmental stressors. Assessing the consequences of increasing hypoxia to aquatic food webs is a critical need to predict future mercury exposure to human and ecosystem health.

**Kaitlyn D Read**, Lake Simcoe Region Conservation Authority, Newmarket, ON, Canada. **Adapting to Change: Climate change research and initiatives in the Lake Simcoe watershed.**

Climate change is projected to impact the Lake Simcoe watershed in various ways, from warmer water temperatures altering aquatic ecosystems, to wilder storms causing more flooding and contaminant loading, to longer growing seasons allowing more invasive species to thrive. The Lake Simcoe Region

Conservation Authority (LSRCA) has been working to both mitigate and adapt to these changes, within the authority as well as throughout the Lake Simcoe watershed. To guide this work, LSRCA has completed several strategies to outline their climate change program and frame the shift to a more sustainable and resilient future. The goals of the program are to decrease the carbon footprint of the watershed (through both reducing emissions and increasing sequestration) and to assess the potential effects of a changing climate on watershed function. Over the past years, LSRCA has undertaken numerous initiatives to achieve these goals, including watershed planning and monitoring, supporting municipal climate readiness, facilitating knowledge transfer, completing risk and vulnerability assessments, and quantifying carbon sequestration in restored ecosystems. Through strong collaboration and adaptive management, progress towards these goals will continue into future decades.

**Kate Read-Maney** and Nandakumar Kanavillil, Lakehead University, Orillia, ON, Canada. **Microscopic aquatic epiphytes as bioindicators of water quality in the wetlands of Lake Simcoe.**

Wetlands are unique ecosystems providing important functions such as water filtration, carbon storage, and habitats for flora and fauna. Increase in human population and anthropogenic activities in the recent times have resulted in a continuous degradation of wetlands. This study was conducted to observe and compare the changes in microscopic aquatic epiphyte populations found on wetland macrophytes as an indicator of wetland water quality. The study has been conducted in two major Ontario fringe wetlands, the Holland Marsh and Lagoon City around Lake Simcoe. The macrophytes studied as the host species of microscopic epiphytes were *Typha angustifolia* and *Nymphaea odorata*. The major water parameters monitored included conductivity, pH, dissolved oxygen, chlorophyll a, heavy metals, and plant nutrients. Phytoplankton composition was also analyzed. The epiphytes were extracted by scrapping a known area of the macrophytes using a clean brush. The epiphytes were studied using a haemocytometer under a compound microscope. The results showed statistically significant variation in epiphyte density and diversity, between the macrophyte species. Although the species richness did not show a significant difference between wetlands, the species composition showed variation with Holland Marsh showing a higher epiphyte density, an increased number of pollution tolerant species, and poor water quality parameters. This study revealed the importance of monitoring wetland water quality using epiphytes as bioindicators for a better management of wetland ecosystems.

**Euan D Reavie**[1] and Elizabeth E Alexson[2], [1]University of Minnesota Duluth, Duluth, MN, USA, [2]Natural Resources Research Institute, University of Minnesota, Duluth, MN, USA. **Paleolimnology supports AOC delisting and recommendations for post-AOC goals.**

A lack of historical data hinders understanding of environmental problems, particularly when these data are critical to track the positive effects of remediation. For instance, since the St. Louis River Estuary (SLRE) was listed as an Area of Concern (AOC) in 1987, actions were taken to restore water quality in hopes to eventually remove beneficial use impairments (BUIs). A paleolimnological study of the SLRE was initiated to close data gaps in nutrient, sediment and algal loads. Paleorecords provided clear evidence that management has reduced the flux and concentrations of nutrients in the estuary, and the biological community responded positively, thereby supporting removal of BUIs. However, the apparent persistence of high nutrients in some areas, and evidence of increasing cyanobacterial blooms indicate that stressors (e.g., climate change, legacy nutrients) that were not well understood in the 1980s are concerning. So, in addition to supporting AOC delisting, these long-term records can provide recommendations for post-delisting efforts to deal with contemporary problems such as harmful algal blooms. Additional paleolimnological tools are available to deal with a variety of BUI unknowns, demonstrating the inimitable value of paleolimnology to provide the long-term context needed to support AOC delisting throughout the Great Lakes basin. Considering these results, a new effort to retrospectively understand nearshore conditions has been initiated at multiple locations around the Great Lakes.

**Jody Lynn Rebek**, Algoma University, Sault Ste Marie, ON, Canada. **Action Research investigating freshwater stewardship and blue economy perspectives.**

Located in the nexus of the upper Great Lakes, we connect to 20% of the planet's freshwater. Engaging our local community is critical to understanding and co-creating actions that will rehabilitate freshwater. This multidisciplinary Community-Based Action Research aims to investigate challenges and opportunities of freshwater restoration, along with social, economic, and cultural skills. Phase-1 focused on freshwater perspectives/culture, and investigated the freshwater Blue Economy, via surveys. The surveys examined sustainable entrepreneurship opportunities, barriers and resident perspectives in Algoma and Chippewa regions relating to freshwater restoration and sustainability. This laid the groundwork for engaging community members in phase-2 data collection. Research findings will be shared, and participants will engage in dialogue to co-create collective actions in a Catechization Cafe (Sameshima, 2019). The dialogue will include community members in crafting a blue community strategy that intends to bring a hopeful and diversified perspective regarding stewardship and sustainable entrepreneurship opportunities. Note: Dr. Jody Rebek and Dr. Ahmed Aziz, Faculty of Business & Economics, Algoma University Hannah Caicco, Western University Alejandra Pascagasa, Universidad Santo Tomás

**Jessica Reid**[1], Jennifer Lamoureux[2], Jonathan D. Midwood[3], Sean Landsman[1] and Steven Cooke[1], [1]Carleton University, Ottawa, ON, Canada, [2]Rideau Valley Conservation Authority, Ottawa, ON, Canada, [3]Fisheries and Oceans Canada, Burlington, ON, Canada. **In or Out? Tracking the movements of freshwater fishes in rehabilitated stormwater pond habitat.**

River ecosystems are experiencing cumulative stressors including wide-scale fragmentation from urbanization and agricultural activities. This can lead to the degradation and/or complete loss functional aquatic habitat, which are considered some of the most significant threats to freshwater species today. In Ottawa, land-use changes associated with urban sprawl may be impacting small, urban rivers such as the Jock River by decreasing riparian and floodplain habitat, increasing sedimentation and other sources of pollution, and altering channel morphology. The quality of small streams, off-channel ponds, and floodplain habitat on the Jock River is expected the further decrease as development continues, putting critical spawning and nursery areas for fishes at risk. A decade ago, a decommissioned stormwater management pond was rehabilitated and reconnected to the Jock River but did not receive any follow-up monitoring. To determine the extent to which fishes use this restored area, we used Passive Integrated Transponders to track the summer movements of 20 fish species. We seek to better understand what biodiversity benefits a rehabilitated SWMP may provide to urban ecosystems in terms of species richness and access to spawning and juvenile nursery habitat. By evaluating the effectiveness of this pond, we will directly inform the future planning of similar conservation efforts in urban Ottawa.

**Kaitlin L Reinl**[1], Ted D Harris[2], Rebecca L North[3], Pablo Almela[4], Stella A Berger[5], Mina Bizic[5], Sarah H Burnet[6], Hans-Peter Grossart[5,7], Bastiaan W Ibelings[8], Ellinor Jakobsson[9], Lesley B Knoll[10], Brenda Lafrancois[11], Yvonne McElarney[12], Ana M Morales-Williams[13], Ulrike Obertegger[14], Igor Ogashawara[5], Ma Cristina Paule-Mercado[15], Benjamin L Peierls[16], James A. Rusak[17,18], Siddhartha Sarkar[19], Sapna Sharma[20], Jessica V. Trout-Haney[21], Pablo Urrutia-Cordero[22], Jason J Venkiteswaran[23], Danielle J Wain[24], Katelynn Warner[13], Gesa A Weyhenmeyer[9] and Kiyoko Yokota[25], [1]Lake Superior National Estuarine Research Reserve, University of Wisconsin-Madison, Superior, WI, USA, [2]Kansas Biological Survey and Center for Ecological Research, Lawrence, KS, USA, [3]School of Natural Resources, University of Missouri, Columbia, MO, USA, [4]Department of Biology, Universidad Autónoma de Madrid, Madrid, Spain, [5]Leibniz Institute of Freshwater Ecology and Inland Fisheries, Department of Plankton and Microbial Ecology, Stechlin, Germany, [6]Department of Fish and Wildlife Sciences, University of Idaho, Moscow, ID, USA, [7]Institute of Biochemistry and Biology, Potsdam University, Potsdam, Germany, [8]Department F.-A Forel for Environmental and Aquatic Sciences, University of Geneva, Geneva, Switzerland, [9]Uppsala University, Dept. of Ecology and Genetics/Limnology, Uppsala, Sweden, [10]Department of Biology, Miami University,

Oxford, OH, USA, [11]National Park Service, Ashland, WI, USA, [12]Agri-Food and Biosciences Institute, Newforge Lane, Belfast, Ireland, [13]Rubenstein School of Environment and Natural Resources, University of Vermont, Burlington, VT, USA, [14]Research and Innovation Centre, Fondazione Edmund Mach, San Michele all'Adige, Italy, [15]Biology Centre of the Czech Academy of Sciences, Institute of Hydrobiology, České Budějovice, Czech Republic, [16]Lakes Environmental Association, Bridgton, ME, USA, [17]Dorset Environmental Science Centre, Ontario Ministry of the Environment, Conservation and Parks, Dorset, ON, Canada, [18]Department of Biology, Queen's University, Kingston, ON, Canada, [19]Geosciences Division, Physical Research Laboratory, Ahmedabad, India, [20]York University, Toronto, ON, Canada, [21]Department of Environmental Studies, Dartmouth College, Hanover, NH, USA, [22]Department of Biology, Lund University, Lund, Sweden, [23]Department of Geography and Environmental Studies, Wilfrid Laurier University, Waterloo, ON, Canada, [24]7 Lakes Alliance, Belgrade Lakes, ME, USA, [25]Department of Biology, State University of New York College at Oneonta, Oneonta, NY, USA. **Blooms also like it cold.**

Cyanobacterial blooms, occurring in small ponds to the Great Lakes, have substantial direct and indirect negative impacts on freshwater biodiversity and ecosystem functions. There is growing concern over the potential for climate change to promote cyanobacterial blooms, as the positive effects of increasing lake surface temperature on cyanobacterial growth are well-documented in the literature. There is increasing evidence, however, that potentially toxic cyanobacterial blooms can also be initiated and persist in cold-water temperatures (<15 °C), even under ice. This work documents cold-water cyanobacterial blooms in freshwaters around the world. In this presentation, we evaluate abiotic drivers and physiological adaptations leading to cold-water cyanobacterial blooms, offer a typology of these lesser-studied phenomena, and discuss their occurrence under current and future climate conditions.

**Jeffrey J Ridal**, Courtney Holden and Matthew JS Windle, St. Lawrence River Institute, Cornwall, ON, Canada. **Legacy mercury contamination in the St. Lawrence River: consideration of climactic factors in long term monitoring.**

Long term monitoring (LTM) programs are commonly instituted to track the success of remediation programs for contaminated sediments in Areas of Concern and other impacted sites in the Great Lakes. For instance, a LTM program forms part of Cornwall Sediment Strategy (CSS) to address legacy mercury contamination of the St. Lawrence River Area of Concern (AOC) near Cornwall, Ontario. Fish sampling was conducted in 2017 to establish baseline concentrations for the long-term monitoring plan. Species collected included Yellow perch, Round goby and Fallfish from nearshore contaminated and reference zones. Results varied significantly with concentrations determined in preliminary sampling in 2016 warranting the collection of fish from upstream reference locations as part of every monitoring event as baseline levels instead of establishing set baseline goals. Additional fish sampling was conducted in 2022 and will be analyzed relative to baseline samples collected in 2017 to assess against the CSS targets and whether any significant change has occurred between sampling intervals. Climactic factors such as inter-annual variations of water temperature, water level fluctuations and flow rates will be examined to assess possible contributions to the variability in mercury concentrations in fish.

**Thornton Ritz** and John Farrell, State University of New York College of Environmental Science and Forestry, Syracuse, NY, USA. **Abiotic conditions impact survival of stocked young-of-year Northern Pike in Upper St. Lawrence River wetlands.**

Great Lakes coastal wetlands are critical nursery habitat for assemblages of young-of-year (YOY) native fishes. Water temperature and dissolved oxygen (DO) significantly influence early growth of YOY fish and can be a limiting factor in recruitment from these habitats. Northern Pike (*Esox lucius)* are a prominent member of the wetland YOY community and represent a native species of ecological and recreational importance. To understand how abiotic conditions impact YOY pike survival, 48,047 individuals were batch marked with oxytetracycline (OTC) and released into four Upper St. Lawrence River wetlands. Each stocking location contained a DO/water temperature data logger which took measurements

of hourly abiotic conditions. After leaving the habitats undisturbed for a month, hoop nets were placed in wetland channels to capture YOY pike emigrating from nursery habitat. Otoliths were dissected from captured YOY pike and viewed for the presence of an OTC mark. Recapture rates were used as a proxy for survival and incorporated into a survival model framework. Candidate models were developed and compared using Akaike Information Criterion (AIC) scores. The best-fit model indicated that increases in DO and declines in water temperature positively influenced the survival of stocked YOY pike. Pairing environmental monitoring arrays with fish stocking is a valuable tool to identify important nursery habitat conditions and their impact on survival.

**Sarah Rixon**[1], Jana Levison[1], Andrew Binns[1], Pradeep Goel[2], Hannah May[1] and Ahmed Elsayed[1], [1]University of Guelph, Guelph, ON, Canada, [2]Ontario Ministry of the Environment, Conservation and Parks, Etobicoke, ON, Canada. **Using isotopic tracers to explore relationships between hydrologic processes and nutrient flux in rural Ontario.**

Reconceptualizing nutrient transport in combination with hydrologic processes may aid in the development of more resilient management plans, particularly as the climate continues to change. Within the Great Lakes Basin there are many pathways of nutrient transport including surface runoff, groundwater flux and tile drainage flow. There remains a lack of understanding on how the relationships between the various pathways contribute to excess nutrient transport to the Great Lakes. The objective of this study is to monitor water quality and quantity to identify vulnerable times and locations that interactions between hydrologic components affect nutrient transport. Research is conducted in the Upper Parkhill watershed in southwestern Ontario (127 $km^2$). Land use is mainly agricultural, consisting of low permeability soils. Water quality and quantity is monitored at a watershed scale (five surface water sites and eight wells), and at an Edge-of-Field (EoF) site. The EoF site features data from groundwater, soil water, hyporheic zone water, tile flow, and surface water. Nutrients and stable isotopes of water ($\delta$18O and $\delta$2H) are collected from all water compartments and used for water quality and hydrologic process markers. Preliminary results indicate surface water and groundwater nutrient concentrations can become elevated in response to variations in seasonal and event-based climate conditions. Methods developed in this study are relevant to policy makers, scientists and landowners to understand current and future climate impacts on watershed health.

**Daniel M. Robb**[1], Roger Pieters[1,2] and Gregory A Lawrence[1], [1]Department of Civil Engineering, University of British Columbia, Vancouver, BC, Canada, [2]Department of Earth, Ocean and Atmospheric Sciences, University of British Columbia, Vancouver, BC, Canada. **Turbidity variations in the epilimnion of a glacier-fed reservoir.**

We have been investigating the variation of turbidity in the surface waters of Carpenter Reservoir, British Columbia, Canada. This long (~50 km) and narrow (~1 km) reservoir receives glacially-turbid meltwater, and there is concern that this turbidity limits light availability in the reservoir and, in turn, limits biological productivity. To address these concerns, we use a combination of field observations, numerical simulations and analytical scaling arguments. Vertical profiles of temperature and turbidity indicate that during summer, inflows plunge below the thermocline and travel along the bottom of the reservoir. The load of glacial particles entering the reservoir is highest in summer, yet turbidity in the epilimnion declines due to thermal stratification isolating the epilimnion from plunging glacial inflows and suspended particles settling from the epilimnion to the hypolimnion. However, episodic wind events upwell turbid fluid to the surface waters. Numerical simulations support the notion that wind-driven upwelling in summer contributes to a small turbidity flux into the epilimnion. Changes in turbidity along the length of the epilimnion are determined by wind-driven fluxes, longitudinal dispersion and particle settling.

**Dale M Robertson**[1], Matthew W. Diebel[1], Luke C. Loken[1] and David A Saad[2], [1]U.S. Geological Survey, Upper Midwest Water Science Center, Madison, WI, USA, [2]U.S. Geological Survey, Water Mission Area,

Madison, WI, USA. **Using model-load ratios to improve estimation of nutrient loading from unmonitored watershed areas.**

Evaluating the effects of wide-scale nutrient management efforts in watersheds requires routine estimates of nutrient loading from the entire watershed for use in watershed assessments and downstream modeling efforts. However, monitoring of the Great Lakes watershed, like most systems, consists of monitoring a limited number of sites that are only periodically evaluated. Here, we describe an approach using load ratios of monitored sites to unmonitored areas from a watershed model to extrapolate the monitored loads from a limited number of reference sites to the total daily and long-term loading from large watersheds. Nonpoint model-load ratios between monitored tributaries (reference sites) and nearby unmonitored areas and point-source delivery factors were obtained from a Spatially Referenced Regression On Watershed attributes (SPARROW) model. These ratios were used to extrapolate nutrient loads from a consistent ongoing monitoring program (the Great Lakes Restoration Initiative Tributary Monitoring Network) to that from the entire U.S. part of the Great Lakes watershed. The model-ratio approach incorporates spatial variability in point and non-point nutrient sources, watershed characteristics, and daily hydrology that are not typically used when estimating loads from unmonitored areas, such as in the drainage-ratio extrapolation approach.

**Kelly Filer Robinson**[1], Michael L. Jones[2], Brian Brenton[3], Richard Clark[4], Jory L. Jonas[5], Matthew Kornis[6], Daniel O'Keefe[7], Brian Roth[8], Iyob Tsehaye[9] and Benjamin Turschak[10], [1]U.S. Geological Survey, Georgia Cooperative Fish and Wildlife Research Unit, Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA, USA, [2]Dept. of Fisheries & Wildlife, East Lansing, MI, USA, [3]Brenton Consulting, LLC, Northville, MI, USA, [4]Quantitative Fisheries Center, Michigan State University, East Lansing, MI, USA, [5]Michigan Department of Natural Resources, Charleviox, MI, USA, [6]U.S. Fish and Wildlife Service, Green Bay Fish and Wildlife Conservation Office, Green Bay, WI, USA, [7]Michigan Sea Grant, Michigan State University Extension, West Olive, MI, USA, [8]Department of Fisheries and Wildlife, Michigan State University, East Lansing, MI, USA, [9]Wisconsin Department of Natural Resources, Madison, WI, USA, [10]Michigan Department of Natural Resources, Charlevoix Fisheries Research Station, Charlevoix, MI, USA. **Updated decision analysis for salmonine stocking in Lake Michigan.**

Lake Michigan's salmon fisheries depend on maintaining a sustainable balance between these predators and their prey. Balance is managed mainly by adjusting stocking numbers which can affect trophic ecology, stakeholder satisfaction, and economic outcomes. Currently, a ratio of estimates of Chinook salmon to alewife biomass is used to monitor predator-prey balance. Decisions informed by this ratio account for other salmonines as equivalent to the number of Chinook salmon consuming a similar amount of food. We used decision analysis to engage fishery managers and stakeholders to identify priorities and evaluate the effects of different stocking strategies on desired outcomes. We updated models and data with the most relevant knowledge to assess salmon and alewife stocks when predicting species' responses to stocking decisions. We explicitly considered the dynamics of predators other than Chinook salmon and updated associated diet data in our predictive models. Most of the stocking practices evaluated resulted in a high risk of large declines in alewife abundance, negatively affecting future salmon fisheries. However, results were very sensitive to recent estimates of alewife productivity, an area of substantial uncertainty, with additional uncertainty around estimated levels of salmonine natural reproduction. It is difficult to confidently account for risk associated with varying stocking practices. Decision makers on Lake Michigan would benefit greater understanding of alewife recruitment dynamics to reduce uncertainty when accounting for risks.

**Emily L Robson**[1], Evlyn Sun[1], Karen Kidd[1], Ryan Prosser[2], Patricia Gillis[3], Jim Bennett[3] and Joseph Salerno[3], [1]McMaster University, Hamilton, ON, Canada, [2]University of Guelph, Guelph, ON, Canada, [3]Environment and Climate Change Canada, Burlington, ON, Canada. **Happy as a clam? Abundance of microplastics in bivalves collected from an urban river.**

Microplastics (MPs) enter aquatic environments through many sources, including wastewater treatment plants (WWTPs), but their uptake by aquatic organisms is poorly understood. Freshwater bivalves accumulate multiple contaminants, making them potential indicators for MP pollution. This study aims to understand the abundance and characteristics of MPs that accumulate in wild bivalves. Samples were collected upstream and downstream of 3 municipal WWTPs and at 2 reference sites along the Grand River (Ontario) in 2021. At each site, fingernail clams (*Sphaeriidae*, n=5 composite samples), flutedshell mussels (*Lasmigona costata*, n=10), and surface water (n=3) were sampled and MPs quantified. Results show that fibers are the dominant morphology across samples, but colours vary among sites and sample types. Additionally, the abundance of MPs varies significantly among sites; although no significant differences between upstream and downstream sites were observed. To assess suitability as an effective bioindicator for MPs, the abundance and type of particles in bivalves will be compared between species and to environmental levels observed in water samples. This study will guide future monitoring and toxicity studies to fully assess the risk of MPs to vulnerable freshwater bivalves and other organisms in the Great Lakes.

**Jessica Robson**[1], Catherine M Febria[2] and Ken G Drouillard[1], [1]Great Lakes Institute for Environmental Research, University of Windsor, Windsor, ON, Canada, [2]Healthy Headwaters Lab, University of Windsor, Windsor, ON, Canada. **Benthic macroinvertebrate and bacteria communities along Detroit River tributary wetlands.**

The Detroit River is a Great Lakes Area of Concern (AOC) with beneficial use impairments to benthic assemblages along the U.S. locations and recently re-assessed unimpaired benthic communities in Canadian portions of the AOC. However, habitat assessments of wetlands have indicated possible stress at wetland locations receiving inflow from Turkey Creek and River Canard tributaries. The wetlands have been shown to range from moderately degraded to very degraded using a water quality index. This study examines benthic macroinvertebrate and bacteria assemblages at tributary wetlands for differences within the wetland bed and the tributary inlet. Climate change in the Great Lakes region is expected to continue impacting aquatic organisms. An understanding of tributary influence on community assemblages can assist in informing monitoring in these sensitive areas. Multivariate analysis indicated significant differences at Turkey Creek for both macroinvertebrate and bacteria communities such that macroinvertebrate communities arrange primarily by benthic habitat characteristics whereas bacteria communities are more directed by water quality parameters.

**Madison Rodman**[1] and Tiffany Sprague[2], [1]University of Minnesota Sea Grant Program, Duluth, MN, USA, [2]Natural Resources Research Institute, University of Minnesota Duluth, Duluth, MN, USA. **Supporting community solutions through the Lake Superior Great Lakes One Water Community of Practice.**

The Lake Superior Great Lakes One Water (GLOW) Community of Practice (CoP) is a catalyst for collaborative community-engaged work on water quantity and quality challenges. GLOW is a supportive network of non-profit, municipal government and academic partners and is a space for connecting, sharing resources and building capacity to collectively increase our community's resilience. Since its founding in 2018 the Lake Superior GLOW CoP has centered its work on equitably addressing and serving marginalized communities - those most vulnerable to and with the fewest means to adapt to water challenges. In this poster we will share how GLOW is both fostering critical community-government collaborations and helping to communicate climate and water science in the western Lake Superior region. A special focus will be a case study of current efforts in the Lincoln Park neighborhood of Duluth, Minnesota where we are working with and engaging the community on visioning and implementation of green infrastructure solutions at the small, neighborhood block scale. GLOW's framework for community engagement and CoP model can be applied and replicated by scientists and outreach professionals to build resilience to water challenges across the Great Lakes region.

**Paul J. Roebber**, University of Wisconsin at Milwaukee, Milwaukee, WI, USA. **Statistical modeling of historical and future Lake Michigan-Huron water levels.**

We construct a water budget model of Lake Michigan-Huron, considering (annual) inputs from precipitation, runoff, and inflow (from Lake Superior) and outputs from over-water evaporation (modified by ice cover) and outflow (to the lower lakes). We also consider regulation of Lake Superior water levels, and to accomplish that, we perform similar modeling for Lake Superior. The model uses historical statistics to produce 1000 fifty-year lake samples representing the expected range of behaviors, accounting for partial correlations between atmospheric drivers. This is then extended using regional climate model data to future scenarios, which suggest more extreme highs and lows but a mixed response in average levels (this latter being sensitive to increases in precipitation alone). Extension to the lower Great Lakes is planned, allowing for a full assessment of potential future water level control strategies, taking into account both upstream and downstream implications of those approaches in the context of a rapidly changing climate.

**Daniel Rokitnicki-Wojcik**[1], Kristina R Heinemann[2], Marie-Claire Doyle[1] and Daniel J Gurdak[3], [1]Environment and Climate Change Canada, Burlington, ON, Canada, [2]US EPA Region 2, Centerport, NY, USA, [3]US EPA Region 2, New York, NY, USA. **An assessment of binational phosphorus targets for Lake Ontario.**

The Lake Ontario watershed is characterized by both urban and rural landscapes, with stretches of pristine shoreline as well as areas of degradation and areas in recovery. These contrasts reflect the lake's nutrient conditions, as nutrient enrichment and signs of eutrophication exist in certain parts of the lake's nearshore zone, while low phosphorus concentrations endure in open waters. The 2012 Canada-U.S. Great Lakes Water Quality Agreement commits the Canada and the U.S. to assess whether revisions to the interim loading target and substance objective for each of the Great Lakes are needed to meet a series of Lake Ecosystem Objectives to improve or maintain aquatic ecosystem health. The Nutrients Annex Subcommittee established the Lake Ontario Objectives and Targets Task Team and directed it to conduct a scientific assessment to recommend whether the interim substance objective and loading target should be revised for Lake Ontario. The Task Team was led by U.S. EPA and ECCC and represented perspectives from a range of areas of expertise, including food web ecology, limnology, fisheries science and management, and modelling. This presentation will provide an overview of the assessment and highlight its findings, recommendation and priority actions.

**Benjamin Rook**[1,2], Yu-Chun Kao[3], Randy L. Eshenroder[2], Charles R Bronte[4] and Andrew M Muir[2], [1]Michigan Department of Natural Resources, Charlevoix, MI, USA, [2]Great Lakes Fishery Commission, Ann Arbor, MI, USA, [3]U.S. Fish and Wildlife Service, La Crosse, WI, USA, [4]U.S. Fish and Wildlife Service, New Franken, WI, USA. **Historical cisco population declines in Green Bay, Lake Michigan, with estimates of abundance during 1945–1957.**

Historically, Green Bay, Lake Michigan, supported one of the largest cisco (*Coregonus artedi sensu lato*) fisheries in the Laurentian Great Lakes, but the fishery collapsed during the late 1950s. Cisco failed to recover, and questions related to causes of population declines remain. We estimated adult and age-1 cisco abundances and evaluated the relative importance and effects of overfishing, interactions with rainbow smelt *Osmerus mordax*, and pollution (hypoxia) on cisco in Green Bay during the period immediately preceding fishery collapse (1945–1957). Stochastic, age-structured simulation models suggested that cisco were exploited at rate of 23%, which was 8% higher than the maximum sustainable level of 15%. Median estimates of cisco abundance were 56 million adult fish and 70 million age-1 recruits. Rank-order correlations suggested that estimates of adult rainbow smelt abundance were strongly and negatively correlated with estimates of adult cisco abundance three years later. Irreversible cisco population declines began at least four years after indicators of prolonged hypoxic conditions were first observed. Collectively, our findings suggest that a combination of overfishing and interactions with adult rainbow smelt during the first year of life likely caused initial cisco population declines in Green Bay, whereas continued interactions

with rainbow smelt and hypoxia resulting from excessive pollution likely prevented cisco from recovering, even in the near absence of commercial exploitation.

**Rebecca Rooney**[1], Laura Beecraft[2], Gabby Izma[3], Rachel McNamee[1] and Emilie Montreuil Strub[1], [1]University of Waterloo, Waterloo, ON, Canada, [2]Harte Research Institute, Corpus Christi, TX, USA, [3]University of Waterloo, Kitchener, ON, Canada. **Wetland biofilm - a key primary producer and agent of water purification.**

Wetlands are both highly productive and hotspots of biogeochemical transformation, contributing to water purification, nutrient pollution abatement, and climate change mitigation. Wetland biofilms, the slimy coating of microbes that covers submersed plants and sediments in wetlands, are key agents of their primary production and nutrient cycling functions. Biofilms are also important in the entrapment and breakdown of aquatic contaminants, like microplastics and pesticides. We contend that biofilms play a critical and underappreciated role in several of the ecosystem services that wetlands provide. Combining the results of observational and manipulative experiments, we report on the important contributions of biofilms to primary production in wetlands, to the entrapment of microplastics, and to the removal and breakdown of pesticides like glyphosate. We also report on the potential risk that contaminated biofilms can present to wetland food webs, as biofilms are key food sources for invertebrates, tadpoles, and larval fish. If wetlands are keystone ecosystems, we contend that biofilms are foundational to several of the ecosystem services that make wetlands so important.

**David Rose** and Karen Alofs, University of Michigan, School for Environment and Sustainability, Ann Arbor, MI, USA. **Testing temperature preference and critical thermal maximum across walleye populations.**

Intraspecific variation in fish, particularly temperature preference and critical thermal maximum (CTmax), can reflect the vulnerability of species to extreme warming events in the face of climate change. Using fingerling fish, we examined the temperature preferences of three Michigan walleye (*Sander vitreus*) populations across a latitudinal gradient in a shuttle-box arena. We then tested the CTmax of the same fish. We found no significant difference in the preference or CTmax across the test populations. We found several limitations of shuttlebox experiments to reliably capture differences in thermal preferences for walleye. Additionally, we developed a new method for calculating preference which excludes periods where fish do not appear to regulate temperature. With this new method, we found a preferred temperature for Michigan walleye that closely mirrors the reported temperature of optimal growth. Results suggest that Michigan walleye populations are likely similarly vulnerable to extreme warming events.

**Greg Rose**[1], Marta Lopez-Egea[2], Milad Taghipour[1], Katherine Gaudreau[3] and Cherie-Lee Fietsch[3], [1]WSP, Mississauga, ON, Canada, [2]WSP, Ottawa, ON, Canada, [3]Bruce Power, Tiverton, ON, Canada. **Modelling techniques for determining climate change implications on thermal risk to Great Lakes fish (with ID 1211).**

Establishing a robust understanding of climate change implications to Great Lakes fish requires suitable tools with which to promulgate climate change-driven atmospheric influences into the lake environment and deliver the requisite spatial and temporal information to generate meaningful characterizations of thermal exposure to resolve population-scale risks. Meteorological modelling techniques have advanced to allow climate change output from Global Circulation Models to be regionally downscaled to drive meteorological models at the Great Lakes scale. These models can then simulate weather-field realizations for various Representative Concentration Pathways and produce output to apply to lake models to simulate lake processes and provide the temperature predictions necessary to assess thermal aquatic risk at the local population level for different climate realizations. This capability is useful for examining climate change effects on lake temperatures, but also of value for examining the thermal effects from power plants

in the presence/ absence of these climate realizations. Decadal projections of lake temperatures for baseline climatic conditions and up to 2060 under varying climatic realizations, were developed to examine thermal exposure in Lake Huron under operational and non-operational conditions using these techniques and segregated into their component parts to provide the information required to assess risk, determine the degree to which risk is tied to operational or climate effects and to assess potential mitigation measures.

**Guylaine Ross**[1] and Chelsea Lobson[2], [1]Government of the Northwest Territories, Yellowknife, NT, Canada, [2]Lake Winnipeg Foundation, Winnipeg, MB, Canada. **Driving decisions in Canada's 'western great lakes' through long-term community-based monitoring.**

Canada's largest lake basins span hundreds of thousands of square kilometres. At this scale, freshwater management can be limited by a lack of long-term data. Community-based monitoring programs (CBM) are filling important data gaps to address concerns about watershed health. In this presentation we will draw on examples from the Mackenzie River Basin and the Lake Winnipeg watershed to illustrate how CBM programs are driving innovative, informed, and collaborative management decisions at different scales (together, these drainage basins cover approximately 28% of Canada's landmass!). In the first case, data collected by communities through the Northwest Territories-wide CBM program are shared locally and contribute to the cross-jurisdictional Mackenzie River Basin Transboundary Waters Master Agreement. In Manitoba, the Lake Winnipeg CBM Network complements existing government monitoring programs to create a robust, continuous dataset that enables a geographically targeted approach to phosphorus-reduction efforts. In each case, collaboration across sectors is key to moving from data collection to impact. Finally, we will discuss how these programs have leveraged DataStream – an open-access platform for sharing water quality data – to make information available to communities and decision-makers in standardized, accessible formats.

**Christopher I Rounds**, University of Minnesota Twin Cities, Minneapolis, MN, USA. **Model comparison for evaluating changes in inland lake ice cover.**

Lake ice is ecologically and culturally important. In temperate climates, many freshwater organisms rely on ice for key stages of their lifecycle. Due to climate change, ice dynamics are changing. As lake ice changes, it is imperative that we are able to understand differences for estimating how lake ice will change temporally and in waterbodies with different physical attributes. Minnesota has an untapped resource of lake ice data, and this dataset can be used to inform how different models predict lake ice changes across lake types. Using three different modeling approaches I describe how lake ice has changed from 1948-2021. Mixed effects random forests had the lowest RMSE while random forests and Generalized Additive mixed models had higher RMSEs. These results indicate mixed effect random forests are useful when applied to ecological data and that including a random effect for lake can accurately predict changes in lake ice cover.

**Christopher I Rounds**[1], Todd Arnold[1], Josh Dumke[2], Eric Larson[3], Anna Totsch[2], Samantha Garcia[3], Katie Edblad[2] and Gretchen JA Hansen[4], [1]University of Minnesota Twin Cities, Minneapolis, MN, USA, [2]University of Minnesota Duluth, Duluth, MN, USA, [3]University of Illinois Urbana Champaign, Urbana, IL, USA, [4]University of Minnesota, St. Paul, MN, USA. **Who, what, when, where, and how: Optimizing eDNA sampling for detecting multiple aquatic invasive species.**

Aquatic invasive species (AIS) threaten lake ecosystems and economies. In Minnesota, over 800 waterbodies contain one or more known AIS. However, this number is likely an underestimate due to the lack of a widespread, standardized AIS monitoring program. This is partly due to traditional monitoring for AIS being time and resource intensive. Environmental DNA (eDNA) has the potential to alleviate these issues, but many questions persist about how eDNA AIS detection probability can be optimized across multiple species with different life histories. To quantify time-varying probability of detection of AIS using eDNA sampling, we sampled 21 lakes at 10 sampling locations 5 times over the open water season. Each

lake had known populations of invasive common carp, rusty crayfish, spiny water flea, and zebra mussels. We used quantitative Polymerase Chain Reaction with species-specific assays to determine presence of each species in water samples. Using occupancy models, we quantified the effects of lake characteristics and sampling season on eDNA detection probability. Our results suggest that optimal eDNA sampling varies seasonally and is related to the species' life history. Our results will provide guidance to those interested in using eDNA as a monitoring tool.

**Katie Rousseau**[1], Shelby Brunner[1], Ana Sirviente[1], Michael Twiss[2], Abraham Francis[3], Ryan Lauzon[4], Mary-Claire Buell[5], Barbara L Wall[6,7], Chris Furgal[6], Chad J LaFaver[8] and Kevin Donner[9], [1]Great Lakes Observing System, Ann Arbor, MI, USA, [2]Faculty of Science, Algoma University, Sault Ste Marie, ON, Canada, [3]Clarkson University, Potsdam, NY, USA, [4]Chippewas of Nawash Unceded First Nation, Wiarton, ON, Canada, [5]Collective Environmental / Trent University, Peterborough, ON, Canada, [6]Trent University, Peterborough, ON, Canada, [7]Trent University, Keene, ON, Canada, [8]Little Traverse Bay Bands of Odawa Indians, Kincheloe, MI, USA, [9]Little Traverse Bay Bands of Odawa Indians, Harbor Springs, MI, USA.

**Indigenous Partnerships with GLOS.**

Within the Great Lakes basin, the Smart Great Lakes Initiative aims to advance technology applications that improve our understanding, use, conservation and relationship with the Great Lakes. One of the Initiative's goals in its common strategy is to ensure Smart Great Lakes provides opportunities and resources for the Indigenous Tribes, First Nations, and Métis within the Great Lakes basin through respectful engagement. As one of the Smart Great Lakes Initiative's partners, the Great Lakes Observing System (GLOS) is a non-profit organization whose mission is to serve Great Lakes data to the public, and it has a strong interest to support monitoring efforts that are important Indigenous communities. GLOS has partnered with a number of Indigenous communities and nations on recent projects. These partnerships are resulting in identification of Indigenous data management needs and concerns such as data sovereignty; GLOS is working with the partners to create practical solutions. Furthermore, GLOS has initiated discussions on these issues to its federal parent organization and regional sister programs as a means to learn from one another and create synergy on the solutions. This presentation will share the partnership efforts between GLOS and the Indigenous communities, the issues raised, the proposed solutions, and future directions.

**Mark D. Rowe**[1], Reza Valipour[2] and Todd Redder[3], [1]NOAA GLERL, Ann Arbor, MI, USA, [2]Environment and Climate Change Canada, Burlington, ON, Canada, [3]LimnoTech, Ann Arbor, MI, USA.

**Intercomparison of three spatially-resolved, process-based Lake Erie hypoxia models.**

Lake Erie hypoxia models have been developed for multiple objectives, including development of phosphorus loading targets, and forecasting hypoxic zone location and movement. Nutrient management objectives have focused on spatially-averaged metrics, including the mean hypoxic area or mean hypolimnetic dissolved oxygen (DO). However, modeling spatial patterns of bottom DO is also important for predicting impacts on drinking water intakes, benthic habitat, and biogeochemical cycling of nutrients. A previous binational effort used multiple models to guide setting phosphorus load reduction targets to achieve ecosystem objectives under the Great Lakes Water Quality Agreement. Models were assessed individually, using different sets of observations, obscuring differences in modeled spatial patterns of hypoxia. In a first binational effort, we compared three previously-developed Lake Erie hypoxia models. The three models were similar in prediction of hypoxic area, but differed in terms of spatial patterns of hypoxia. Several differences in model constructs likely contributed to varying predictions of hypoxia spatial patterns, including sources and sinks of DO in the water column, parameterization of sediment oxygen demand, simulation of vertical mixing, and representation of atmospheric and riverine forcing. This study shows the importance of comparing models using a common set of observations and metrics before generating ensemble modeling load-response curves to better inform lake management applications.

**Freya E. Rowland**[1], Craig A. Stow[2], Laura T. Johnson[3] and Robert M. Hirsch[4], [1]U.S. Geological Survey, Columbia, MO, USA, [2]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, USA, [3]Heidelberg University NCWQR, Tiffin, OH, USA, [4]U.S. Geological Survey, Reston, VA, USA.
**Normalizing Lake Erie tributary concentrations and loads to reduce flow variability.**

Establishing tributary load targets to reduce anthropogenic nutrient inputs to receiving waters is a common mitigation strategy in freshwater and coastal ecosystems. However, detecting and quantifying trends can be challenging because annual precipitation strongly influences tributary flow. This may obscure trends because wet years tend to produce high tributary loads despite management activities to reduce nutrient export, and dry years typically generate low loads, even without management efforts. Furthermore, flow and nutrient concentrations are often correlated. Earlier efforts to reduce the effect of flow variability on tributary nutrient assessment were limited by computational and methodological constraints, until the weighted regressions on time, discharge, and season (WRTDS) method was developed in 2010. We use WRTDS to assess nutrient concentration and load changes in three tributaries to the western basin of Lake Erie from 1982 to 2022. Generally, trends revealed by flow-normalization do not contradict those of non-normalized metrics; however, flow-normalization made the patterns more perceptible and reduced the influence of a particularly wet or dry period at the end of records on long-term trend analysis. We demonstrate that using WRTDS for flow-normalization removed the noise arising from annual precipitation variability and makes tributary nutrient trend evaluation more straightforward.

**James W. Roy**[1], Victoria Propp[2], Tammy Hua[2], Amila De Silva[3] and James E Smith[2], [1]Water Science and Technology Directorate, Environment and Climate Change Canada, Burlington, ON, Canada, [2]McMaster University, Hamilton, ON, Canada, [3]Environment and Climate Change Canada, Burlington, ON, Canada.
**Aquatic life exposure to per- and poly-fluoroalkyl substances (PFAS) of groundwater landfill plumes.**

Historic landfills commonly produce plumes of contaminated groundwater, as many lack liners and leachate collection systems. Aquatic ecosystem exposure can then result where these plumes reach nearby surface waters. Recent work has revealed that leachate from historic landfills often contains per- and poly-fluoroalkylated substances (PFAS). This study investigated PFAS exposure to aquatic organisms of an urban stream (closed 1960s) and a rural pond (with outflow stream; closed 1970s) at two historic landfill sites. Total concentrations of 19 common PFAS reached 30 and 2.6 μg/L, for the stream and pond sites, respectively, within the shallow sediments (epibenthic zone) in hotspot locations within the discharging plume footprint. The overlying surface water (epibenthic and pelagic zones) exhibited substantial PFAS concentration dilution for the stream, but less so for the pond. The landfill-sourced PFAS concentrations of the streams exiting both sites showed substantial dilution, with mass discharge off-site estimated at over 50 and 9 g/yr for stream and pond sites, respectively. Both epibenthic and pelagic zones experienced some seasonal or event-related variation. These findings demonstrate that aquatic organism exposure to PFAS can be substantial at and downstream of historic landfill sites, but can vary markedly between aquatic zones and types of receiving waters.

**Daniel Ruane**, Ohio State University, Columbus, OH, USA. **29-year quantification of soil carbon sequestration rates in constructed wetlands.**

Each year in the U.S., 60,000 acres of natural wetlands are lost to development. To compensate for this, these wetlands must be "replaced" elsewhere by constructed wetlands to comply with "No Net Loss" policies, which aim to mitigate wetland surface area loss. While wetlands have the potential to significantly reduce atmospheric CO2, there is a lack of literature tracking how much carbon constructed wetlands sequester as they age. This knowledge gap precludes policy makers from knowing the long-term benefits that constructed wetlands provide. The Olentangy River Wetland Research Park is a facility that is uniquely qualified to address this knowledge gap. Two constructed riverine wetlands in this park have some of the longest running datasets for constructed wetlands. I have identified 32 sites within these wetlands that were

sampled in 1993, 1995, 2004, 2013, and 2022. My study will be the first to quantify carbon sequestration in constructed wetland soils over a 29-year, continuous timescale. These results will clarify mature constructed wetlands' role in carbon sequestration, which will inform design, management, and legislation of wetland conservation and construction. Furthermore, these data can speak to whether "No Net Loss" policies are promoting wetland development that ensure long-term quality of these carbon sinks.

**Dan Rucinski**, Todd Redder and Derek Schlea, LimnoTech, Ann Arbor, MI, USA. **LEEM: A 3-Dimensional, Unstructured Finite-Volume Ecosystem Model for Lake Erie.**

Ecosystem services in Lake Erie continue to be negatively affected by the impacts of eutrophication processes in the system. *Microcystis* blooms in the western basin, "dead zones" in the central basin, and *Cladophora* growth in the eastern basin are threatening drinking water quality, recreation, tourism, and Lake Erie's fishery. To assess the potential benefits of large-scale nutrient reduction strategies to address these concerns, as prescribed by Annex 4 of the Great Lakes Water Quality Agreement, LimnoTech has developed a state of the science ecosystem model for Lake Erie. This model, referred to as LEEM (Lake Erie Ecosystem Model) has the ability to simulate cyanobacteria, hypoxia and benthic algae responses to management scenarios. The model uses an unstructured computational domain and is based on the FVCOM hydrodynamic model, linked with a custom advanced aquatic ecosystem model. Calibration and management scenario output will be presented and discussed.

**Mica Rumbach** and Kevin McCluney, Bowling Green State University, Bowling Green, OH, USA. **Top-down effects of wetland invertebrates on nutrients via macrophytes and biofilm.**

Nitrogen (N) and phosphorus (P) are key nutrients that have been implicated in toxic algal blooms and the eutrophication of Lake Erie. Wetlands can be used to mitigate nutrient runoff by storing these nutrients in pools of varying sizes. Few studies have examined the effect of animals on nutrient cycling in these systems. The effects of invertebrates on N and P nutrient pools and whole-system nutrient uptake was determined using field mesocosms in a recently constructed wetland at Oakwoods Nature Preserve (Findlay, OH) in the Western Basin of Lake Erie. Emergent wetland macrophytes and biofilm were exposed to different treatments of aquatic macroinvertebrates – snails (grazers), crayfish (omnivores), or no invertebrates (control). Six nutrient pools of N and P were measured: surface water, sediment, biofilm, aquatic animals, pore water, and plants. Additionally, whole-system nutrient uptake was examined following a nutrient pulse that mimicked spring conditions. We expected that aquatic macroinvertebrates would selectively reduce the sizes of certain nutrient pools through consumption, altering nutrient uptake. The presence or abundance of these invertebrates could be related to hydroperiod and understanding their influence on nutrients could have implications for future wetland design. Preliminary data suggests that snails and crayfish decrease dissolved N and P compared to controls. The data also suggest that dissolved N and P uptake is rapid (i.e. 24 hours).

**Adam Rupnik**[1], Timothy B Johnson[1], Aaron Fisk[2], Dimitry Gorsky[3], Silviya V Ivanova[4], Sarah Larocque[5], Graham Raby[6] and Jonathan D. Midwood[5], [1]Ontario MNRF, Glenora Fisheries Station, Picton, ON, Canada, [2]School of the Environment, University of Windsor, Windsor, ON, Canada, [3]U.S. Fish & Wildlife Service, Amherst, NY, USA, [4]GLIER, University of Windsor, Windsor, ON, Canada, [5]Fisheries and Oceans Canada, Burlington, ON, Canada, [6]Trent University, Peterborough, ON, Canada. **Multi-species analysis of seasonal movement corridors for Lake Ontario fishes.**

Understanding the distribution and movement of fishes is critical to effective management, especially in light of on-going ecological change. Acoustic telemetry is a valuable tool for investigating the movement patterns for many economically and ecologically important fish species within the Great Lakes. While many studies have used acoustic telemetry to investigate general movement patterns, few have compared bathymetric depth corridors used for movement amount multiple species across seasons. Further,

this analysis resulted from multiple projects collaborating to share detection data from previously tagged fish, reducing overall costs while expanding the scope of the research. From 2018 to 2022, 29 acoustic receivers were deployed in to parallel lines ranging in depth from 5 to 105 meters in east-central Lake Ontario. Thirteen different species were detected with Lake Trout (*Salvelinus namaycush*), Chinook Salmon (*Oncorhynchus tshawytscha*), Lake Whitefish (*Coregonus clupeaformis*), and Walleye (*Sander vitrius*) being detected most frequently. While bathymetric depth preferences differed among species, inter-annual differences within species were minimal, offering insight into preferred movement corridors for fishes within the central basin. Understanding these corridors for fish movement offers greater insight into seasonal habitat utilization that can inform traditional and telemetric survey design and our understanding of fish behavioural patterns.

Sebastian Theis[1,2], Ryan Scott[2], Andrea Chreston[3], Angela Wallace[2], Brynn Coey[2], Rick Portiss[2] and **Jonathan Ruppert**[3,4], [1]University of Alberta, Edmonton, AB, Canada, [2]Toronto and Region Conservation Authority (TRCA), Vaughan, ON, Canada, [3]Toronto and Region Conservation Authority, Vaughan, ON, Canada, [4]Department of Ecology and Evolutionary Biology, University of Toronto, Toronto, ON, Canada.
**Habitat enhancement monitoring at Tommy Thompson Park.**

Tommy Thompson Park, constructed on Leslie Street Spit, a constructed land-form extending into Lake Ontario, is one of the largest restoration projects in the Great Lakes Aside from its popular destination as a park and wilderness area, Tommy Thompson Park features extensive aquatic restoration and enhancements which are monitored as part of the Toronto and Region Remedial Action Plan as well as other programs, like fish habitat assessments conducted by the Toronto and Region Conservation Authority. Since 1995, restored aquatic habitat has been enhanced further through the introduction of different habitat features like logs or stones. Here we use fish and benthic invertebrate data from the restored and enhanced areas within Tommy Thompson Park to evaluate the status of the current fish and invertebrate community. Analyses were done with the goal of determining if restored and enhanced habitats meet the community targets outlined in the Remedial Action Plan. Aside from community changes and species presence over time, our focus was on whether Tommy Thompson Park provides sufficient habitat for all fish life-stages and if community gaps point towards missing habitat types or conditions? Finally, we consider invasive species like Common Carp and Round Goby, with Carp being restricted through exclusion gates, and Round Goby potentially contributing to the prey base of the food web within Tommy Thompson Park. The results of our analysis will be used to help assess restoration efforts, to guide future monitoring efforts, and to assist with future decision making.

**Camilla Ryther**[1], Ryan Lauzon[2], Mary-Claire Buell[3], Ruth Duncan[4] and Erin S. Dunlop[5], [1]Trent University, Peterborough, ON, Canada, [2]Chippewas of Nawash Unceded First Nation, Wiarton, ON, Canada, [3]Collective Environmental / Trent University, Peterborough, ON, Canada, [4]Trent University, Owen Sound, ON, Canada, [5]Ontario MNRF, Trent University, Peterborough, ON, Canada. **Spawning behaviour of dikameg (lake whitefish) revealed using fine-scale acoustic telemetry.**

Dikameg (lake whitefish) support an important cultural, commercial and subsistence fishery for the Saugeen Ojibway Nation (SON) in Lake Huron. Dikameg recruitment has dramatically declined, yet little is known about the species' spawning behaviour. In this study, we are using Two-Eyed Seeing to characterize sex-specific patterns in activity and habitat associations of dikameg during spawning. A Vemco Positioning System was deployed at an active spawning shoal, with input provided based on SON's Ecological Knowledge. In 2020, 50 fish were captured and tagged (V16-4X tags) and 26 of those fish were observed the following spawning season. A clear bell-shaped pattern was observed in the number of unique fish returning to the spawn shoal area over the course of the spawning period. Males and females both showed clear diel patterns of movement, although they moved within the VPS array in distinct ways. This research presents a unique opportunity to work with an Indigenous Nation to understand dikameg spawning

behaviour, providing insights into the reproductive biology of a population undergoing concerning declines in recruitment.

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**Jaita Saha**, Sigrid Peldszus and Peter M. Huck, University of Waterloo, Waterloo, ON, Canada. **Can microplastics in Great Lakes water enter our drinking water?.**

The Great Lakes are an important source of drinking water production. The substantial usage of different plastic products and their subsequent fragmentation, deposition, and accumulation in the ecosystem are the main contributory reasons behind the notable appearance of MPs in the Great Lakes. These Lakes are the source of drinking water production for millions of Canadian and US citizens, and though it is as of yet uncertain whether the presence of MPs in drinking water may pose a health hazard, it is important to ascertain if MPs are removed during drinking water treatment. There has been an increasing number of publications performing full-scale drinking water treatment plant (DWTPs) surveys and bench-scale surveys looking at MPs removal. The goal of this research is to conduct a meta-analysis of these existing published research studies on the presence of MPs in drinking water sources and their removal through full-scale DWTPs in general and through individual, mostly conventional treatment units i.e., coagulation-flocculation-sedimentation and filtration units at both full-scale and bench-scale levels. The synthesis of data derived from these studies carried out around the world provides insights into the effectiveness of drinking water treatment processes and the presence of MPs in finished drinking water. Moreover, this research helps to understand the importance of standardizing appropriate methods for the detection of MPs and treatment of water. The analysis also aims to show the necessity of developing a regulatory framework for the presence of MPs.

**Ratnajit Saha**, Alex Neumann, Carlos Alberto Arnillas and George B. Arhonditsis, Ecological Modeling Laboratory, Department of Physical and Environmental Sciences, University of Toronto, Toronto, ON, Canada. **Quantify agricultural impacts on GHG emissions at major cash crops farms in a changing climate in Ontario, Canada.**

Canada has committed to the Paris Agreement to reduce greenhouse gas (GHG) emissions by 30% below 2005 levels by 2030 and net zero by 2050. Agricultural practice is a significant contributor to the GHG emission, and the extension of farms is being continued, especially in Ontario. GHG reduction from the field will aid in reaching the emission reduction target. Therefore, it is essential to determine the magnitude and uncertainty in GHG estimates and assess the net impact of agricultural farms on GHG emissions. At the farm level, the GHG emission factors are dynamic, and some uncertainties are associated with GHG inventory. This study aims to quantify agricultural GHG emissions from major cash crop farms in a changing climate in Ontario, Canada. Knowledge of farm management practices from farmers, county-wise crop data, and climatic parameters (observed and general circulation model) dataset are being used. The Holos model (version 4.0), an empirical farm-scale model developed by Agriculture and Agri-Food Canada, is being used to calculate GHG (carbon dioxide, nitrous oxide, and methane) emissions for major cash crop farms in different ecozones in Ontario. In addition, we are expanding the concept of "Virtual Farm" in the context of dynamic environmental factors to estimate the impact of various management practices, fertilizer inputs, and climate influence. The expected farm-scale GHG inventory and virtual farm would help us to identify the largest GHG contributing sources, the best ways to reduce emissions, and improve farm management strategies.

**Halima Salah**[1], Yaoxian Huang[1], Ying Xiong[1], Debatosh Partha[1], Noribeth Mariscal[1], Simone Tilmes[2] and Wenfu Tang[2], [1]Wayne State University, Detroit, MI, USA, [2]National Center for Atmospheric Research,

Boulder, CO, USA. **Global Intercomparisons of Impacts of Air Pollution on Air Quality and Human Health.**

There exists substantial spatial and temporal variability of gridded short-lived climate forcers (SLCFs) emissions from the state-of-the-science global bottom-up anthropogenic emission inventories, resulting in uncertainties in atmospheric chemistry, air quality and human health impacts. In this study, we firstly inter-compared the global annual total and spatial variability of SLCFs for the year 2015 from Community Emissions Data System (CEDS), the Copernicus Atmosphere Monitoring Service (CAMS), Evaluating the Climate and Air Quality Impacts of Short-Lived Pollutants version 6b (ECLIPSEv6b). We then employed the Community Atmosphere Model coupled with chemistry version 6.0 (CAM6-Chem) within the Community Earth System Model version 2.2.0 at the horizontal resolution of 0.95° latitude by 1.25° longitude to quantify the atmospheric chemistry and air quality impacts from the above three inventories, with a focus on $PM_{2.5}$ (particulate matter with aerodynamic diameters equal or less than 2.5 microns) and ozone ($O_3$). Lastly, we conducted an inter-comparison of global human health impacts from the inventories attributable to long-term $PM_{2.5}$ and $O_3$ exposure.

**Thomas Saleh**[1], Chris Hay[2], Chris Herc[3], Madeline Stanley[4], Jeff Simpson[5], Dilber Yunus[2] and Pauline Gerrard[2], [1]IISD - Experimental Lakes Area, Toronto, ON, Canada, [2]IISD - Experimental Lakes Area, Winnipeg, MB, Canada, [3]Grand Council Treaty 3, Kenora, ON, Canada, [4]University of Manitoba, Winnipeg, MB, Canada, [5]Aquatic Life Ltd., Pinawa, MB, Canada. **Supporting local community science through data and technology.**

Technologies for data collection and data processing are advancing at a dizzying pace, providing community-based monitoring groups with more tools than ever before. While some of these innovative technologies are designed for ease of use, others can present technical or financial barriers to access. For the past several years, IISD-ELA's team of freshwater scientists have been working with local First Nations, organizations, and tech entrepreneurs to facilitate the adoption of new technologies in freshwater monitoring. This work has involved three complementary approaches. The first approach has been to provide technical and educational support to community-based monitoring initiatives, in particular those led by Grand Council Treaty 3 and Treaty 3 communities. Secondly, IISD-ELA has partnered with local businesses to pilot new monitoring technologies and identify potential applications with public benefits. Such benefits might include more reliable data from remote locations or real-time warnings of environmental events. Thirdly, IISD-ELA is committed to sharing the large volumes of data collected from its lakes, located on Treaty 3 lands in North-Western Ontario, as well as data gathered from related freshwater initiatives. These datasets can provide local scientists with a better understanding of freshwater ecology and lake health in the region. These three approaches contribute to a common objective of connecting communities with the scientific and technological resources they need to better monitor, care for, and defend their lakes and rivers.

**Chelsea Salter**[1] and Chris Grant Weisener[2], [1]University of Windsor, Windsor, ON, Canada, [2]Great Lakes Institute for Environmental Research, University of Windsor, Windsor, ON, Canada. **Elucidating microcystin-LR degradation in Lake Erie sand through metabolomics and metatranscriptomics.**

Across the world, cyanobacterial harmful algal blooms pose a serious environmental threat by impairing water quality, specifically through the production and release of a hepatotoxin named microcystin (MC). Observed microbial degradation of MC-LR occurring in Lake Erie is not supported to be controlled by a known mechanism governed by the mlr gene operon. Pelee Island is uniquely situated in the western basin of Lake Erie and repeated yearly exposure to MC-LR has enabled the bacterial community along the shore to establish the means of metabolizing the toxin. A multi-omic approach combining metabolomics, metatranscriptomics, and metataxonomics was employed to thoroughly investigate the mechanism controlling MC-LR degradation by the Pelee Island sand community over 48 hours. Detected metabolites indicated that epoxidation may be an important mechanism employed to initiate degradation. The cleavage

of bonds surrounding N atoms suggests a targeted isolation of nitrogen by the microbial community. Methylotrophic denitrification was a dominant process governing the cycling of carbon and nitrogen and supports a critical role of nitrogen in MC-LR degradation. The culmination of these results reveals the complexity of the Pelee Island sand community and supports a mutualistic metabolism is employed between microbial species.

**Amber Sample**[1], Sarah Saunders[2], Izabela Grobelna[2], Alice Van Zoeren[3], Francesca Cuthbert[4] and Jillian Farkas[5], [1]ORISE Participant with US EPA, Chicago, IL, USA, [2]Audubon, Traverse City, MI, USA, [3]University of Minnesota, Saint Paul, MN, USA, [4]University of Minnesota, Dept. Fisheries & Wildlife, St. Paul, MN, USA, [5]US Fish and Wildlife Service, East Lansing, MI, USA. **Using ArcGIS StoryMap to engage with the public about Great Lakes Piping Plovers conservation.**

The Great Lakes Piping Plover (*Charadrius melodus*) is a federally endangered shorebird threatened by habitat loss, human disturbance, and predation. Once faced with a very low population size, these birds have begun to make a remarkable comeback thanks to the efforts of the Great Lakes Piping Plover Recovery Team of federal and state agencies, non-governmental organizations, academic researchers, conservationists, and volunteers. However, engaging with the public to increase awareness, stewardship, and advocacy around Great Lakes Piping Plover conservation remains challenging. In collaboration with Audubon Great Lakes and with input from the Recovery Team, we developed an ArcGIS StoryMap to increase public engagement through storytelling via interactive maps, photos, and videos. As an educational and outreach tool, the StoryMap includes public beach nesting locations in the Great Lakes region, overwintering locations along the Atlantic and Gulf coast, plover stories, Recovery Team personnel spotlights, and recommendations for what the public can do to support plover conservation efforts. Educating the public about Great Lakes Piping Plovers is critical to fostering enthusiasm and support for recovery efforts, helping to ensure the species' long-term recovery. Combined with other engagement activities, such as outreach events, the StoryMap is another tool that can be used to inspire the public to advocate for plovers in the Great Lakes and beyond.

Sierra Rae Green[1], **Carol Sandberg Waldmann**[2], Sara Hughes[3], Xinjie Wu[1], Emily Dusicska[1], Kathy Sun[1], Subba Rao Chaganti[4], Casey M Godwin[4], Michael E. Fraker[1] and Henry A. Vanderploeg[5], [1]University of Michigan, Ann Arbor, MI, USA, [2]Michigan State University, Hickory Corners, MI, USA, [3]University of Michigan, Ann arbor, MI, USA, [4]Cooperative Institute for Great Lakes Research, University of Michigan, Ann Arbor, MI, USA, [5]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, USA. **Nutrient Management in Lake Erie: Evaluating Stakeholder Values, Attitudes, and Policy Preferences.**

Harmful algal blooms (HABs) have impaired Lake Erie's western basin water quality consistently since the 1960s. The problem is twofold: (1) uncertainty in the specific causes of HABs leads to inept management solutions, and (2) managing a cross-boundary watershed requires collaboration and agreement on apt solutions from multiple stakeholders as well as many U.S. states and Canadian provinces. In this study, we interviewed 29 stakeholders actively involved in western Lake Erie's watershed. We analyzed the stakeholders' values, attitudes, and policy preferences to understand their differences, similarities, and their effects on management decisions. We found that stakeholders agree on the urgency of the problem and the necessity for increased nutrient management in Lake Erie's western basin. Furthermore, we found that stakeholders can be represented as distinct clusters based on their values, and these value-based clusters are associated with different policy preferences. However, the different opinions and preferences of these value clusters span across stakeholder sectors and may affect efforts toward policy change. Stakeholders often question the feasibility and effectiveness of existing policies and policy plans. The findings shed new light on the relationship between stakeholder type and environmental values, attitudes, and policy preferences. Collaboration on HABs in Lake Erie will require open lines of communication both to improve policy and to cultivate trust among the multiple parties in this diverse watershed.

**Michael J. Sayers**[1], Peter C Esselman[2], Robert A. Shuchman[1], Ben Hart[1], Zane Almquist[1], Karl Bosse[1] and Lu Buller[1], [1]Michigan Tech Research Institute, Ann Arbor, MI, USA, [2]U.S. Geological Survey, Great Lakes Science Center, Ann Arbor, MI, USA. **Characterization of bottom reflectance in Lake Michigan using in fused in situ radiometry and underwater imaging.**

Submerged aquatic vegetation (SAV) is important to the health or freshwater systems as they provide crucial habitat to an array of aquatic organisms. In light of this, better understanding of freshwater SAV dynamics, in light of a changing climate, is a necessary step to develop robust ecological management practices. The Michigan Tech Research Institute (MTRI) in collaboration with USGS GLSC has developed an underwater hyperspectral radiometer system that integrated onto the USGS Iver3 underwater vehicle to characterize benthic reflectance. The Iver3 is equipped with a stereo-imaging system capable of estimating bottom type and SAV biomass. Together, these systems will be able to provide a database of bottom albedo and associated SAV parameters which are essential for development of hyperspectral remote sensing algorithms. MTRI tested this system in Lake Michigan in August 2020 and 2021 with initial results suggesting the system is capable of producing robust estimates of bottom albedo of different bottom types including variable SAV percent cover. In this study, we use a fuzzy classification scheme to link bottom spectral reflectance information to substrate type and SAV cover. We found mean spectral clusters were associated with significantly different bottom compositions, suggesting the importance of considering variable bottom albedo in remote sensing algorithms moving forward. Finally, we generated an initial spectral library of water leaving radiances for common bottom types encountered in Lake Michigan.

**Paris Kim Schofield**[1], Amanda Ackiss[2] and David B. Bunnell[2], [1]University of Michigan School for Environment and Sustainability, Ann Arbor, MI, USA, [2]USGS Great Lakes Science Center, Ann Arbor, MI, USA. **Temporal Genetic Diversity of Cisco (*Coregonus artedi*) in Lake Huron.**

Over the past century, Lake Huron has undergone steep declines in its coregonine biodiversity, including Cisco (*Coregonus artedi*). The once abundant Saginaw Bay Cisco population was extirpated by the 1960s, though Cisco have persisted in other regions of the lake. In 2018, a multi-agency effort began to reintroduce Cisco into Saginaw Bay. A key question is how the genetic composition of the extirpated stock compares to contemporary populations. New genomic methods, including genotyping-in-thousands by sequencing (GTseq), have proven successful at amplifying degraded DNA, enabling comparisons of historic and contemporary samples. Here, a GTseq panel developed to identify coregonine species was tested to determine its ability to detect population structure within Lake Huron. Panel loci revealed population structure between contemporary Cisco collected from Parry Sound and elsewhere in Lake Huron, as well as subtle differences between northern and southern Cisco in the main basin. Furthermore, historic Saginaw Bay samples from the 1940s were successfully genotyped and were most similar to contemporary Cisco caught off the Bruce Peninsula. Understanding genetic diversity in the context of ongoing research on Cisco morphology and ecology will provide managers with critical information for continued restoration efforts.

**Claire Schon**[1], Michael J McTavish[2], Robert Bourchier[3] and Rebecca Rooney[1], [1]University of Waterloo, Waterloo, ON, Canada, [2]University of Toronto, Toronto, ON, Canada, [3]Agriculture and Agri-Food Canada, Toronto, ON, Canada. **Protecting Great Lakes wetlands using biological control.**

Invasive *Phragmites australis* is a highly invasive grass in many Great Lakes wetlands. Moth-based biological control is a promising new tool for *P. australis* management. Two stem-boring moth species, which are natural predators of *P. australis* in Europe, were approved for Canadian release in 2019, but their efficacy in suppressing invasive *P. australis* has never been tested in the field. We will present the first data on *P. australis* suppression efficacy in North America, based on biocontrol releases of *Archanara neurica* and *Lenisa geminipuncta* conducted in Spring 2022. We measured damage to *P. australis* inflicted by each moth species released alone and in combination, including measurements of stem density, flowering density, moth larval damage density and plant response, species richness, canopy light interception, and standing crop biomass. Many moth-attacked stems died, while those that survived were shorter and typically did not

produce seed. On average, 20% of stems were damaged in plots where moths were release, and on damaged stems we observed a 90% reduction in flowering, 50% reduction in height, and 60% reduction in biomass. Moth-based biological control offers a new frontier in invasive *P. australis* management and wetland restoration, with the potential to provide a cost-effective and sustainable approach to invasive species control.

**Matthew O Schrenk**[1], Sherry L Martin[2], Maria C Berry[1] and Amy Vodopyanov[1], [1]Michigan State University, East Lansing, MI, USA, [2]US Geological Survey, Lansing, MI, USA. **How are land uses and environmental geochemistry reflected in microbial communities of the Saginaw Bay Watershed?.**

Microbial communities are ubiquitous in aquatic ecosystems and quickly respond and adapt to changing environmental conditions. Due to recent advances in environmental DNA sequencing technology and analysis, the genetic content of these microorganisms represents a potentially sensitive and high-resolution record of environmental variability and change. A biogeochemical survey of surface waters in the Saginaw Bay watershed was used to generate coordinated geochemical and microbiological data, against a backdrop of detailed maps of land use and hydrologic modeling. Preliminary data from this survey showed variations in microbial abundance and geochemical properties from higher order to lower order streams. Ongoing work is using 16S rRNA gene amplicon and shotgun metagenomic sequences to study the diversity and variability in these aquatic microbial ecosystems. These data are being used to document the correlation between microbial species and environmental characteristics. Functional analyses of the microbial populations are also being used to investigate the record of adaptation in the resident microbial communities. Taken together, this work will be used to pinpoint genetic tracers of specific processes affecting the quality of surface waters in the Saginaw Bay watershed, which can inform future monitoring and management strategies.

**Bailey Schwenk**[1], Elizabeth Kazmierczak[1], Fritz Petersen[1], Xia Zhu[2], Jacob Haney[2], Chelsea Rochman[2], Richard Lammers[3], Emily Lever[3], Wilfred Wollheim[3], Shan Zuidema[3] and Timothy Hoellein[1], [1]Loyola University Chicago, Chicago, IL, USA, [2]University of Toronto Scarborough, Toronto, ON, Canada, [3]University of New Hampshire, Durham, NH, USA. **Stormwater-mediated transport of macroplastic litter in urban watersheds.**

Rivers influence the amount, timing, and form of plastic litter moving downstream. Stormwater is a source of plastic pollution into waterways and a key component of plastic export. However, few studies have quantified plastic movement before, during, and after storms throughout a river continuum. Measuring abundance of plastic during stormflow is challenging and requires new field approaches. We adapted a remote camera-based observation method to detect floating macroplastic. We deployed this method at 12 stream sites across three watersheds in North America (including the Don, Ipswich, and Chicago rivers). At each site, we recorded video of the river surface before, during, and after individual storm events. We used weather forecasts and flow gauges to determine the start and end times of stormwater influx, as well as the rising and falling limb of stormwater flow. We predict that the rising limb will have the highest macroplastic flux at all sites. We hypothesize that the abundance of watershed urbanization will be positively correlated to total macroplastic transported. We also hypothesize that downstream sites will have higher macroplastic abundance than upstream sites. These data will help expand our understanding of how plastics move through freshwater environments, and inform new models of watershed plastic dynamics.

**Thomas Sciscione**, Toronto and Region Conservation Authority, Vaughan, ON, Canada. **Waterfront integrated restoration prioritization: a tool for improving aquatic habitat.**

Under the Remedial Action Plans for the Great Lakes, the Toronto and Region AOC lists the Beneficial Use Impairment (BUI) of Loss of Fish and Wildlife Habitat and Degradation of Fish and Wildlife Populations as impaired. A Prioritization Tool is needed to guide aquatic habitat restoration along the

waterfront to achieve delisting targets for Beneficial Use Impairment (BUI) 14 Loss of Fish and Wildlife Habitat and BUI 3 Degradation of Fish and Wildlife Populations and support ongoing restoration efforts post-delisting. Ecosystem restoration planning requires an integrated approach considering many components of the natural system when prioritizing where and what to restore. Toronto and Region Conservation Authority (TRCA) and partners are developing a strategic approach to restoration planning, using the concept of applied science to inform meaningful implementation decisions focusing on priority areas rather than opportunism. The Waterfront Integrated Restoration Prioritization (WIRP) framework uses existing data to reflect different restoration goals, ensuring important habitats and corridor linkages are protected, enhanced or rehabilitated. This is achieved by identifying where impairments to ecological function are located and prioritizing restoration opportunities that could contribute most to improving the existing habitat along the Toronto waterfront. This presentation will outline WIRP methodology and demonstrate how it can be used as a tool to successfully achieve different natural resource planning objectives.

**Anne E Scofield**[1], Tomas O Hook[2], David B. Bunnell[3], Aaron Fisk[4], Joel C Hoffman[5], Timothy B Johnson[6], Brian C. Weidel[7], Harvey A. Bootsma[8], Cecilia E Heuvel[9], Richard Krauss[10], Andrew Scott McNaught[11], Brent Nawrocki[6], Michael Rennie[12], Benjamin Turschak[13], Mark Vinson[14], Marissa Wegher[12] and Paris D Collingsworth[2], [1]US Environmental Protection Agency, Chicago, IL, USA, [2]Illinois-Indiana Sea Grant, West Lafayette, IN, USA, [3]USGS Great Lakes Science Center, Ann Arbor, MI, USA, [4]School of the Environment, University of Windsor, Windsor, ON, Canada, [5]USEPA ORD Great Lakes Ecology and Toxicology Division, Duluth, MN, USA, [6]Ontario MNRF, Glenora Fisheries Station, Picton, ON, Canada, [7]USGS Great Lakes Science Center, Oswego, NY, USA, [8]University of Wisconsin-Milwaukee, Milwaukee, WI, USA, [9]University of Windsor, Great Lakes Institute for Environmental Research, Windsor, ON, Canada, [10]USGS Lake Erie Biological Station, Huron, OH, USA, [11]Central Michigan University, Mount Pleasant, MI, USA, [12]Lakehead University, Thunder Bay, ON, Canada, [13]Michigan Department of Natural Resources, Charlevoix Fisheries Research Station, Charlevoix, MI, USA, [14]USGS Lake Superior Biological Station, Ashland, WI, USA. **Consistent patterns in $\delta^{13}C$ and $\delta^{15}N$ of multiple trophic levels across the Laurentian Great Lakes.**

Stable isotope ratios of nitrogen ($\delta^{15}N$) and carbon ($\delta^{13}C$) are valuable tools for studying food web structure, but broad-scale variations in baseline $\delta^{15}N$ and $\delta^{13}C$ are not well-understood for freshwaters. We use the Great Lakes as a case study to test for variation in isotopic ratios in lakes that exhibit gradients in residence time, watershed characteristics, and trophic state. We used a nested ANOVA to investigate differences in $\delta^{13}C$ and $\delta^{15}N$ of organisms of multiple trophic levels (zooplankton, benthos, rainbow smelt, and lake trout) across lakes and seasons, accounting for within-lake variation due to region and year. There were significant effects of lake on baseline values of $\delta^{13}C$ and $\delta^{15}N$; patterns were generally consistent with expectations, with more oligotrophic lakes (Superior) being relatively depleted and more mesotrophic (Ontario) to eutrophic (Erie) lakes being enriched in both $\delta^{13}C$ and $\delta^{15}N$. Season was a significant factor for $\delta^{13}C$ in all taxa except benthos and for $\delta^{15}N$ in zooplankton and rainbow smelt. Zooplankton and benthos $\delta^{15}N$ values were highly variable, but this variation was dampened in fish, as expected due to integration of prey items over time. Post-hoc analysis of $\delta^{13}C$ and $\delta^{15}N$ versus lakewide average chlorophyll, residence time, and watershed characteristics indicate that these properties are correlated with stable isotopes values. This study suggests that baseline isotopes ratios in large lakes may be predictable based on lake and watershed characteristics, as has been demonstrated for some marine and smaller freshwater systems.

**Ryan Scott** and Rick Portiss, Toronto and Region Conservation Authority (TRCA), Vaughan, ON, Canada. **Assessing the biological response to stream restoration in the Toronto region.**

Urban streams are subject to many stressors including increased runoff and siltation, loss of riparian vegetation, and decreased habitat heterogeneity and quality. In the Greater Toronto Area many stream reaches have been channelized to reduce the severity of stormwater flows, resulting in degraded aquatic

habitat and poor water quality. To restore the natural form and function of these streams while retaining capacity for flood control, the Toronto and Region Conservation Authority undertakes many stream restoration projects incorporating natural channel design techniques. TRCA has also monitored aquatic habitat, water quality, and fish and invertebrate communities throughout the GTA for over 20 years through the Regional Watershed Monitoring Program. We examine monitoring results from two case studies of restoration efforts in the Mimico Creek and Etobicoke Creek watersheds. Physical habitat characteristics and fish populations improved following restoration. However, the response of benthic communities diverged from this pattern with some metrics indicating little or negative response. Utilizing multimetric and multivariate methods to examine subtle changes in benthic community structure in the context of long-term watershed-specific monitoring data, we suggest the biotic response to reach-scale restoration efforts is limited by catchment-scale factors. Our results highlight the challenge of habitat restoration in urbanized watersheds and the importance of incorporating a watershed-scale view in project design and implementation.

**Frank Seglenieks**[1], Andre Temgoua[2] and Narayan Shrestha[3], [1]National Hydrological Service, ECCC, Burlington, ON, Canada, [2]Environment and Climate Change Canada, Quebec City, QC, Canada, [3]ECCC, Burlinton, Canada. **Future Great Lakes water levels and hydroclimate variables under 1.5°C to 3°C warmer climates.**

With the many different interests that are connected to the water levels of the Laurentian Great Lakes, the future of these water levels are of great concern to many people, businesses, and institutions. In this study, projected future hydroclimate variables and lake levels were calculated using data from the North American component of the Coordinated Regional Downscaling Experiment in relation to a 1.5°C, 2.0°C, 2.5°C, and 3.0°C change in global mean temperature. The results show that the projected changes in hydroclimate variables (i.e higher temperatures, increased precipitation and evaporation, etc.) vary by season and location within the basin. As well, with greater changes in the global mean temperature, there is the possibility of more extreme lake levels (on both the high and low end). A greater understanding that the extremes in water levels observed in the past may be exceeded under a changing climate will help in the planning of future developments and activities within the Great Lakes.

**Titus S Seilheimer**[1], Amy Carrozzino-Lyon[2], Colin Ritchie[2] and Noah Hoffmann[2], [1]Wisconsin Sea Grant, Manitowoc, WI, USA, [2]University of Wisconsin - Green Bay, Green Bay, WI, USA. **Fish and wild rice: a recipe for restoration success.**

Green Bay, Lake Michigan was once home to seemingly endless beds of manoomin (wild rice, *Zizania palustris*). This "good berry" provided sustenance for thousands of years along with habitat for fish and wildlife. However, colonial settlement followed by industrialization and development in the last 150 years resulted in the decline of wild rice in Green Bay's coastal wetlands. Since 2016, conservation partners have worked to restore wild rice on the Green Bay west shore. Wetland monitoring indicates success varies generally following an environmental gradient from the mouth of the Fox River in the south to the Menominee River on the border with Michigan. Established rice beds represent a valuable aquatic habitat to grazing waterfowl as well as spawning and nursery habitat for fish. We surveyed fish assemblages using both active and passive gears in two restoration sites that did not have wild rice present and two sites with wild rice growing in the summer of 2022. A total of 30 fish species were observed with yellow perch and banded killifish as most abundant. The highest number of fish species occurred at a site with wild rice, however the second most species rich site did not have wild rice present. Results indicate that Green Bay wetlands serve as important fish habitat but simple presence of wild rice is not a determining factor. However, successful wild rice restoration may be an indicator of diverse, healthy wetland ecosystems that provide valuable benefits to fish, wildlife, and people.

**Patricia Olena Semcesen**[1], Mathew Wells[1], Rafaella Gutierrez[1], Cassandra Sherlock[1] and Chelsea Rochman[2], [1]University of Toronto, Toronto, ON, Canada, [2]University of Toronto Scarborough, Toronto, ON, Canada. **Tagging Trash – investigating transport of floating urban macroplastic debris.**

We used GPS-tracked bottle drifters to investigate and better understand the transport, accumulation, and retention patterns of floating macroplastic debris in and around Toronto Harbour. Plastic bottles which emulate floating plastic debris, were fitted with GPS-trackers and released into Toronto Harbour during the Summer of 2021. A total of 71 drifter datasets were collected. Drifters travelled between 100 m and 300km within two weeks of release and were found with other bottles, microplastics, and macroplastic debris in sheltered areas, trash bins, or stranded onshore. However, most drifters typically became trapped in Toronto Harbour within several days of deployment - only 15% of drifters escaped Toronto Harbour. Thus, most floating plastic debris is expected to be retained within Toronto Harbour. Low drifter densities (0.450-0.459 g/cm$^3$) and high windage-areas (45-51%), resulted in wind-dominated transport and wind factors that can be 10-fold higher than those of water currents. The prevailing southwesterly winds and general anti-clockwise circulation of water currents in Lake Ontario support possible downstream transport of plastic debris to the Atlantic Ocean. This research informs debris-trap installations that reduce down-stream transport of floating plastic debris.

**Kyla Semmendinger** and Scott Steinschneider, Cornell University, Ithaca, NY, USA. **Value of Forecast Lead-Time and Skill in Robust Reservoir Management in the Lake Ontario - St. Lawrence River Basin.**

Outflows from Lake Ontario are regulated at the Moses-Saunders Dam. The current control policy, Plan 2014, is the first of this system to use supply forecasts to inform release decisions. In this work, we use multi-objective optimization to identify alternative control policies to Plan 2014 and explore how these policies perform using forecasts at different lead-times, skill levels, and under plausible future climate scenarios. This information is necessary to understand how policy robustness varies with forecast attribute and how system performance across objectives can change in the future. Specifically, we create forecasts at 1, 3, 6, and 12-month timescales and vary skill between a baseline level and a perfect forecast. We then discover optimal policies using this forecast information under historic supply conditions that balance flood risk reduction, hydropower production, commercial navigation, wetland biodiversity, and recreational boasting. A subset of policies is evaluated under a stochastic and climate-change driven dataset of water supplies to assess policy robustness outside of historical supply conditions. Results from this work are directly supporting decision makers in their review of the current policy and in the formulation and evaluation process of a new operating policy for the system.

**Mahyar Shafii**[1], Stephanie Slowinski[1], Yubraj Bhusal[1], Calvin Hitch[2], William Withers[3], Fereidoun Rezanezhad[1] and Philippe Van Cappellen[1], [1]Ecohydrology Research Group, University of Waterloo, Waterloo, ON, Canada, [2]Toronto and Region Conservation Authority, Vaughan, ON, Canada, [3]City of Richmond Hill, Richmond Hill, ON, Canada. **Statistical modeling of phosphorus loads and speciation in urban catchments under variable landuse.**

Excessive urban phosphorus (P) export may cause eutrophication in downstream water bodies. Predicting urban P loads is therefore key to designing and implementing P abatement strategies, e.g., Low Development Infrastructure (LID). Combining field data, P speciation analyses, and statistical modeling, we quantified P loads in three urban catchments in the Great Toronto Area, with a focus on total P (TP), total dissolved P (TDP), dissolved reactive P (DRP), dissolved unreactive P (DUP=TDP–DRP), and particulate P (PP=TP–TDP). Multiple linear regression (MLR) models were developed to estimate catchment-scale annual P loads. The results yielded P loads that were near the lower limit of ranges reported in the literature. Estimated annual loads of TP were 0.20—0.46 kg ha$^{-1}$ yr$^{-1}$ and, for TDP, DRP, DUP, and PP they were 0.06—0.17, 0.01—0.07, 0.03—0.1, and 0.16—0.29 kg ha$^{-1}$ yr$^{-1}$, respectively. Overall, PP dominated TP loads (72—88%). With increasing percentage of residential area in the watershed, P loading also increased. The

DRP:TP ratio was highest in the catchment with the largest fraction of green space. The variability in P loads and speciation implies that urban P management must be watershed specific.

**Lamees Shah**, Carlos Alberto Arnillas and George B. Arhonditsis, Ecological Modeling Laboratory, Department of Physical and Environmental Sciences, University of Toronto, Toronto, ON, Canada.
**History and advancement of crop modelling.**

Crop modelling is proposed as a useful tool to test various combinations of climates, soils, crop types, and management practices that cannot be thoroughly tested by field experiments without exhaustive time and resources. Common applications of crop models include exploring changes in water balance, nutrient fate and transport, and crop yield in response to climate change or environmentally friendly crop management practices such as cover crops, conservation tillage, or buffer strips. The number of crop models continues to grow, many building upon older algorithms developed in or prior to the 1990s. We review the history and advancement of crop modelling over the decades, identifying areas that still need further development and/or have become increasingly relevant in complex systems. The increase in biodiversity as an important feature introduced with many environmentally friendly management practices is yet to be sufficiently captured by models, such as intercropping or cover crops that are directly seeded into main crops rather than only during fallow periods. Thus, we explore the advances and limitations in common model aspects or algorithms that are critical in modelling diverse systems such as those relating to photosynthetic processes, plant growth, and below-ground processes, and in the same light, compare crop models with models that simulate plants in natural environments.

**Ali Reza Shahvaran**[1], Homa Kheyrollah Pour[2] and Philippe Van Cappellen[1], [1]Ecohydrology Research Group, University of Waterloo, Waterloo, ON, Canada, [2]ReSEC Research Group, Department of Geography and Environmental Studies, Wilfrid Laurier University, Waterloo, ON, Canada. **Potential of multispectral satellite and UAV imagery for nearshore water quality monitoring.**

Over nine million people, primarily from the Greater Toronto Area, rely on Lake Ontario for their drinking water. Because of this and many other valuable benefits and services Lake Ontario provides, comprehensive water quality monitoring is essential. Traditional monitoring, however, is not only time-consuming and costly, it is also often limited resolution in space and time. Remote sensing (RS) using satellite and unmanned aerial vehicle (UAV) observations can potentially complement more traditional methods to deliver high-resolution water quality coverage. Here, three types of near-surface water data are compared: (1) in-situ data on turbidity, total suspended sediment (TSS), and Chl-a, (ii) UAV data captured by a multispectral camera (and then radiometrically and geometrically corrected), and (iii) synchronous Landsat 9 satellite images. The data collection focused on four nearshore locations in Western Lake Ontario: Hamilton Harbour and the Sixteen Mile Creek, Credit River and Niagara River outlets. Using machine-learning techniques, the spectral profiles of matching pixels were then trained and tested using the in-situ data. The proposed approach should be transferable to other littoral lake environments.

**Kirill Shchapov**[1], Kevin Blagrave[1], Edward Todd Howell[2], Nadine Benoit[2], Tara George[3] and Sapna Sharma[1], [1]York University, Toronto, ON, Canada, [2]Ministry of the Environment, Conservation and Parks, Toronto, ON, Canada, [3]Ministry of the Environment, Conservations and Parks, Thunder Bay, ON, Canada.
**Temporal changes in water quality parameters across nearshore regions of Canadian Great Lakes.**

Nearshore habitats in the Great Lakes contain more than 93% of the lakes' biodiversity and provide a source of drinking water and recreational services to more than 30 million people. Despite recent attention to the nearshore regions, the mechanisms of how Great Lakes' nearshore areas and embayments change throughout time and space remain poorly understood. In this study, we analyzed inter- and intra-annual temporal variations in ~40 water quality parameters at 52 nearshore stations of four Great Lakes. Among all lakes, Huron and Superior showed the least variability in water quality conditions between seasons. We

found a positive trend in surface water temperature during fall for Lake Erie and summer and fall for Lake Huron. All lakes showed a general decrease in pH and no changes in chlorophyll *a* values. Across a number of sites in Lake Huron and Lake Ontario, we found an increasing concentration of chloride ions during the spring season, which may result from the use of road salts during winter. To our knowledge, few studies have collected the extent of water quality information across sites and years in the Great Lakes, making our study integral to understanding nearshore temporal and spatial changes. Our results offer new insights into water quality conditions in the most anthropogenically affected habitats of the Great Lakes and can help understand the effects of global environmental change on four of the largest freshwater ecosystems on the planet.

**Wei Shi**[1], Leon Boegman[2], Shi liang Shan[3], Yingming Zhao[4], Aidin Jabbari[5], Josef D. Ackerman[6], Zach Amidon[7], Touhue Yang[8] and Edward F. Roseman[9], [1]Environmental Fluid Dynamics Laboratory, Department of Civil Engineering, Queen's University, Kingston, ON, Canada, [2]Environmental Fluid Dynamics Laboratory, Department of Civil Engineering, Queen's University, Kingston, ON, Canada, [3]Department of Physics and Space Science, Royal Military College of Canada, Kingston, Canada, [4]Aquatic Research and Monitoring Section, Ontario Ministry of Natural Resources and Forestry, Lake Erie Fishery Station, Wheatley, ON, Canada, [5]Fisheries and Oceans Canada, Bedford Institute of Oceanography, Dartmouth, Halifax, NS, Canada, [6]Department of Integrative Biology, University of Guelph, Guelph, ON, Canada, [7]University of Toledo, Lake Erie Center, Department of Environmental Science, Toledo, OH, USA, [8]US Fish and Wildlife Service, Washington, USA, [9]USGS-Great Lakes Science Center, Ann Arbor, MI, USA. **Identifying hatching locations of Walleye in Lake Erie with a backward particle tracking model.**

Walleye (*Sander vitreus*) are an important Lake Erie fish species, supporting valuable recreational and commercial fisheries. Multiple spatially distant spawning stocks produce larvae which contribute to the overall population abundance. However, pelagic larvae are subject to physical transport processes (currents, waves, and turbulence) that can ultimately affect survival and recruitment success. While pelagic larvae have been collected across Lake Erie, transport processes mix larvae from each spawning location so that the relative contribution of each spawning location to overall year-class abundance is indecipherable. To address this issue, we developed a backward particle tracking model, driven by three-dimensional hydrodynamic simulations, to estimate the likely hatching locations of larval walleye observations collected in Lake Erie during 1994-98 and 2017-21. The temporal and spatial distributions of hatching locations were investigated relative to the variation in water currents, water temperature, wave heights, water depth, and substrate type. How these physical variables affect inter-annual and inter-decadal variation in hatching location was also considered. Quantifying the relative year-class contribution of each spawning stock will identify high production spawning areas that are critical to maintaining a healthy walleye population and low production spawning areas that may require rehabilitation.

**Yulu Shi**[1], Mathew Wells[2], Timothy B Johnson[3], Adam Rupnik[3], Jonathan D. Midwood[4], Brian F Lantry[5], Dimitry Gorsky[6] and Bruce Tufts[7], [1]University of Toronto Scarborough, Toronto, ON, Canada, [2]University of Toronto, Toronto, ON, Canada, [3]Ontario MNRF, Glenora Fisheries Station, Picton, ON, Canada, [4]Fisheries and Oceans Canada, Burlington, ON, Canada, [5]USGS, Lake Ontario Biological Station, Oswego, NY, USA, [6]US Fish and Wildlife Service, Basom, NY, USA, [7]Queen's University, Kingston, ON, Canada. **Observations of wind-driven upwelling in Lake Ontario during both summer and winter.**

Winds blowing over the surface of Lake Ontario create currents, which can in turn drive motions of the deeper thermally stratified layers. When wind blows parallel to the shore of this large lake, Ekman currents can result in either large upwelling or downwelling of the thermal stratification. As a dimictic lake, Lake Ontario is thermally stratified in both summer and winter, yet previously only motions of summer thermocline have been investigated. In this paper we analyze data from 13 temperature logger chains and 92 benthic loggers that were deployed for one year across Lake Ontario. In line with previous observations, we

find that during summer stratification, upwelling events with colder water were most frequent at the north-western shore of the lake near Toronto, and downwelling events were most common on the south-eastern shore near Oswego. A highly novel finding is that sites with cooler summer temperatures in the top 20 m of the water column appear to have warmer winter temperatures, while sites with warmer summer temperatures have colder winter temperatures. This pattern is spatially coherent, with the north-western Lake Ontario possessing cooler winter and warmer summer temperatures, while the south and eastern sites have the opposite pattern. We discuss the implications of this finding for fish habitat usage and fisheries management.

**Steven Shikaze**, Steve Holysh, Richard Gerber, Michael Doughty, Mason Marchildon and Britt Smith, Oak Ridges Moraine Groundwater Program, Toronto, ON, Canada. **The Oak Ridges Moraine Groundwater Program – Ontario's leading-edge water resource database and mapping portal.**

The Oak Ridges Moraine is a geologic landform that extends over 160 km from east to west, north of the city of Toronto. This topographic high represents the headwaters of rivers that flow south to Lake Ontario and north to Lake Simcoe and Lake Huron. The permeable sediments of the moraine represent important groundwater recharge areas for aquifers that provide water to over 200,000 people. In its goal of promoting data-driven water resources decision making, the Oak Ridges Moraine Groundwater Program (ORMGP, www.oakridgeswater.ca) has been building and actively managing/maintaining a comprehensive database for over 20 years. At over 100 GB, this database includes geologic, hydrogeologic and hydrologic data from many different sources. Types of data include borehole logs with geologic records, groundwater levels, groundwater chemistry, streamflow data, and geophysics, that has been collected by consultants, academics, and groundwater agencies for groundwater studies across Ontario for decades. The database also includes climate data from Environment Canada and from some of the 15 agencies in the program. In addition to providing access to this database, the ORMGP website also provides data analyses and interpretation (e.g., interpolated water table/potentiometric surface mapping, 3D geologic surfaces available, baseflow separation, graphic and statistical analyses of temporal monitoring data, etc.). This presentation will provide a summary of the database plus a demonstration of the interactive web-based mapping and analysis portal.

**Narayan Shrestha**[1], Frank Seglenieks[2], Étienne Gaborit[3] and Dorothy Durnford[4], [1]ECCC, Burlinton, Canada, [2]National Hydrological Service, ECCC, Burlington, ON, Canada, [3]Meteorological Research Division, ECCC, Dorval, QC, Canada, [4]Meteorological Service of Canada, ECCC, Dorval, QC, Canada. **An assessment of the current and future land hydroclimatology of the Ottawa River Basin.**

The Ottawa River basin (ORB) drains an area of about 146,300 km2 through the Canadian provinces of Ontario and Quebec. While it is a highly regulated basin, with 13 principle reservoirs to manage the streamflow, almost 60% of the basin is still natural. It is the largest tributary of the St. Lawrence River (SLR), as such, the streamflow dynamics of the ORB impacts the downstream reaches of the SLR. Hence, it was necessary to carry out an assessment of the current and future hydroclimatology of the ORB. In this study, we developed a hydrological model consisting of WATFLOOD and RAVEN, in which land-surface processes were represented in WATFLOOD and lake- and river-routing were handled in RAVEN. Furthermore, the main reservoirs were implemented using the Dynamically Zoned Target Release (DZTR) principle. The hydrological model was calibrated and validated against streamflow at several locations and evaluated for snow water equivalent and actual evapotranspiration. The model was then subjected to future projections from different Regional Climate Models (RCMs), driven by several Global Climate Models (GCMs) that participated in the North American component of the Coordinated Regional Downscaling Experiment to assess future changes in hydroclimatology (precipitation, temperature, snowpack and actual evapotranspiration, and streamflow). This information will be used by the Great Lakes-St. Lawrence River Adaptive Management Committee as part of its work on the second phase of an expedited review of the binational regulation plan, known as Plan 2014.

**Rohit Shukla**[1], Leon Boegman[1] and Pankaj Kumar[2], [1]Environmental Fluid Dynamics Laboratory, Department of Civil Engineering, Queen's University, Kingston, ON, Canada, [2]Institute of Meteorology and Climate Research, Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany. **Determination of climate factors driving water quality in Lake Erie using causal discovery approach.**

Climate change affects the physical and biogeochemical processes that occur in lakes, and as a result, harmful algal blooms (HABs) in Lake Erie have become a increasingly serious threat to water quality. It is widely accepted that the occurrence of HABs in freshwater bodies results from complex non-linear interactions between chemical, biological, hydrological, and meteorological processes that take place at different spatial and temporal scales. However, most local condition metrics used by ecologists fail to capture the complex associations between climate and ecological processes. Although deterministic numerical modeling offers an effective means to study HABs, it is challenging to calibrate models that adequately reflect the complexity of HAB dynamics. Unlike numerical models, data-driven models based on machine learning can achieve good predictive performance, but their generalizability and ability to gain process insight are limited. To overcome this challenge, we propose using a causal discovery-based framework to better understand the potential significance and pathways of climatic indicators in Lake Erie HABs dynamics. This approach would not only discover contextualized causal networks but also enable one to reach quantitative conclusions. Here, we identify some of the most important hydroclimatic pathways that greatly improve our knowledge of HABs within Lake Erie. We further discuss this approach's advantages and challenges for water quality management and why it should be standard practice for critical decision making.

**Krystal Siebert**[1], Genevieve Ali[2], Paul K. Sibley[3] and Ben DeVries[1], [1]University of Guelph, Guelph, ON, Canada, [2]McGill University, Montreal, QC, Canada, [3]University of Guelph, Waterloo, ON, Canada. **Climate influences on water quality in Lake Erie.**

The deterioration of lake water quality is a global phenomenon driven by a variety of factors, such as agricultural nutrient runoff, and temperature and precipitation changes. More studies are needed to evaluate the influence of climate variability on lake water quality over multiple decades. Our study aims to understand the relationship between water quality in the western, central, and eastern basins of Lake Erie and climate indices that capture above-lake and contributing watersheds' climate conditions. Remotely-sensed, monthly (May-Oct) chlorophyll data (acquired from NOAA) was retrieved for Lake Erie, from 2002 to 2019. Monthly climate indices were calculated from the Daymet geospatial dataset (acquired from NASA). Spearman's rank correlation coefficients (rho) were then computed between monthly averages of chlorophyll, air temperature lows, air temperature highs, and total rainfall. Preliminary results suggest that above-lake air temperatures are negatively correlated with chlorophyll ($-0.93 < rho < -0.64$), while correlations with above-lake rainfall were not statistically significant. This research will detail basin-specific results and characterize the relative influence of above-lake climate conditions and contributing-watershed climate conditions on lake water quality. This will provide insight into climate-related drivers for long-term water quality changes and potentially alternative climate-related indices to consider in future water quality management solutions.

**Clayton Sigmann**, Michigan State University, East Lansing, USA. **Climate Change Adaptation: The Tourism Industries of the Northwestern Region of Michigan USA.**

Current and projected future climate changes will be a major threat to the tourism industry worldwide. This research seeks to identify adaptation strategies and capacities of critical tourism industries to climate change in Northwest Michigan. This qualitative research first examines climate change projections for the region; second, uses key informant interviews to identify the adaptation efforts on local agriculture, water, and winter-based tourism industries; and finally, assess implications and intervention options. Climate projections from the Great Lakes Integrated Sciences and Assessments (GLISA) for 2041-2070 show that changes in summer precipitation are most important for the water recreation sector; fall and summer

precipitation is most crucial to the agritourism sector; while changes in average winter temperature is the winter recreation sector's greatest concern. Current adaptation efforts include expanding the resilience of coastal formations and infrastructure; selective plantings and harvests; and expanding upon snow making technology. These findings suggest water recreation is most at risk from disruptions; business size and resources limit the adaptation capabilities of the agritourism sector; and the winter recreation sector is actively engaged in adaptation efforts as their industry is considerably vulnerable.

Michael Joseph Donahue[1], **Sanjiv Sinnha**[2], Kavita Kapur McLeod[3], Jen Mathia[4], Lizhu Wang[5], Deborah H. Lee[6] and Gavin Christie[7], [1]AECOM Technical Services, Inc., Traverse City, MI, USA, [2]Environmental Consulting and Technology. Inc., Ann Arbor, MI, USA, [3]KKM Environmental Consulting, Takoma Park, MD, USA, [4]Environmental Consulting and Technology, Gainesville, FL, USA, [5]International Joint Commission, Windsor, ON, Canada, [6]NOAA GLERL, Ann Arbor, MI, USA, [7]Great Lakes Lab. for Fisheries & Aquatic Sci., Burlington, ON, Canada. **Evaluation of the Lake Erie Adaptive Management Framework.**

The International Joint Commission's Science Advisory Board evaluated the effectiveness of the Lake Erie Adaptive Management Framework (LE-AMF) in reducing nutrient over-enrichment. The study examined Annex 4 (Great Lakes Water Quality Agreement); Annex 4 Subcommittee efforts; and Domestic Action Plans (DAPs) supporting the LE-AMF. Progress in establishing the LE-AMF; coordinating planning and implementation; and achieving sustainable institutional arrangements was evaluated via a literature search and document review, survey, interviews, and Project Team consultations. The study concluded that progress has been made, but the full potential of the LE-AMF could be reached by addressing various gaps and unmet needs (e.g., stakeholder engagement, data, DAP inconsistencies, absence of dedicated funding). Recommendations call for improving linkages among domestic/binational adaptive management (AM) processes; institutionalizing the LE-AMF via dedicated funding; strengthening coordination and collaboration by establishing a Lake Erie Group under Annex 4; addressing data gaps and unmet needs; providing additional guidance for DAP implementation; and identifying/applying "best practices" from other AM experiences. The nutrient management issue will be addressed by reviewing its origin, the Annex 4 response, study efforts/outcomes, and applications to the Lake Erie Basin and beyond.

**Lewis Sitoki**[1], Benard Mucholwa Simiyu[2], Harold Sabula Amukhuma[3], William Okello[4] and Rainer Kurmayer[5], [1]Technical University of Kenya, Nairobi, Kenya, [2]Department of Geosciences and The Environment, The Technical University of Kenya, Nairobi, Kenya, [3]Kenya Meteorological Department, Kisumu International Airport Station, Kisumu, Kenya, [4]National Fisheries Resources Research Institute, Jinja, Uganda, [5]Research Department for Limnology, University of Innsbruck, Mondsee, Austria.
**Interannual variability of water quality conditions in the Nyanza Gulf of Lake Victoria, Kenya.**

Nyanza Gulf is considered eutrophic with the massive occurrence of harmful algal blooms dominated by *Microcystis*. The dilution of gulf water occurs through Rusinga and Mbita Channels. Conductivity and phytoplankton biovolume were monitored monthly from July 2017 to July 2018 at three stations (Kisumu Bay (EG), Mid Gulf (MG) and Mbita Channel (WG)) and compared with records of 2008 – 2009. Conductivity showed a distinct increase from the WG to the EG but compared with records 2008–2009 it had decreased. Water exchange between the main lake and the gulf resulted in decreased in conductivity. Transparency was positively related to most phytoplankton genera, whereas *Dolichospermum*, *Microcystis* and *Aulacoseira* were related to eutrophication. The proportion of *Microcystis* decreased during this sampling period while that of *Aulacoseira* increased. Given that Secchi disc and conductivity were significantly negatively correlated it is inferred that most phytoplankton were related to higher transparency. Phytoplankton taxa composition at the WG differed from the composition found at the MG and EG, whereas at the MG and EG, taxa composition was more similar. The observed dilution at the EG was primarily related to the overall increased water level in the main basin, leading to a decline in nuisance blooms and overall improved water quality.

**Stephanie Slowinski**[1], Mahyar Shafii[1], Md Abdus Sabur[1], Alina Arvisais[1], Yubraj Bhusal[1], Konrad J. Krogstad[1], William Withers[2], Chris T Parsons[3] and Philippe Van Cappellen[1], [1]Ecohydrology Research Group, University of Waterloo, Waterloo, ON, Canada, [2]City of Richmond Hill, Richmond Hill, ON, Canada, [3]Environment and Climate Change Canada, Burlington, ON, Canada. **Phosphorus retention performance of a stormwater pond in Richmond Hill, Ontario.**

Stormwater ponds (SWPs) are a common urban runoff control measure that also has the potential to reduce phosphorus (P) loads to downstream receiving waters. Nontheless, the processes controlling phosphorus (P) retention in SWPs are not fully understood. We estimated the loads of various operational P pools between 2020-2021 at the inlet and outlet of a SWP in Richmond Hill, Ontario. The retention efficiencies of dissolved reactive P (DRP), particulate P (PP) and total P (TP) were calculated using multiple linear regression models for the corresponding inlet and outlet loads. We also collected sediment cores from the SWP and performed sequential chemical extractions to characterize the multi-year burial of different sediment-bound P pools. Integrated over the entire study period, the SWP served as a major P sink with over 80% of TP load reduction at the outlet compared to the inlet. The sequential extraction data further provide insight into the mechanisms responsible for the efficient P in situ immobilization that may guide the development of interventions to optimize P reduction by less performing SWPs.

**Marisa Smedsrud**, Erin Graves, Mikela Dean and **Ysabelle Yrad**, University of Michigan, Ann Arbor, MI, USA. **Sustaining Freshwater Services as we Anticipate Climate Change in the Obtawaing Biosphere Region.**

The University of Michigan Biological Station was designated as a Biosphere Reserve by UNESCO in 1979. In 2021, the Biosphere Region was reimagined to include a broad domain stretching across Michigan's Northern Lower Peninsula and Eastern Upper Peninsula. This new Biosphere Region was renamed Obtawaing, reflecting the Anishinabek word meaning "at the halfway place". This newly defined area is hydrologically, ecologically, historically, and socially heterogeneous, leading to several independent management efforts across the Obtawaing Biosphere Region (OBR). To unify the many partners, rightsholders, and general stakeholders within the region, there is an intention to develop a culture of collaboration surrounding freshwater resources. The Obtawaing redesignation offers unlimited potential and, as the Anishinabek word suggests, an opportunity to unite and find common ground in the wake of environmental, societal, and economic downturns. This project focuses on creating a collective understanding and basis for interdisciplinary collaboration through partner interviews and mapping. This project has the opportunity to provide recommendations for how the OBR can establish and maintain a strong emphasis on regional water systems and values as a backdrop for concerted efforts in sustainable development and climate resilience.

**Joeseph Smith**, Sneha Bhadbhade, Linden Brinks, Shelby Brunner and Tim Kearns, Great Lakes Observing System, Ann Arbor, MI, USA. **Standards and cloud first platform for Laurentian Great Lakes data - GLOS Seagull Past, Present, and Future.**

For over a decade, multiple agencies and organizations have collected data across the Laurentian Great Lakes - periodic grab samples, real-time platform data, aerial imagery, and satellite data. As inputs or forcings, those data contribute to the generation of vast amounts of model data as well. The big data challenge has and will continue to be accessing and analyzing those data for decision making and support of broad resource management. Since 2019, the Great Lakes Observing System (GLOS), a Regional Coastal Observing System (RCOS) of the Integrated Ocean Observing System (IOOS), has been developing a standards and cloud computing first platform for the cataloging and collection of various forms of data from the Laurentian Great Lakes basin. We will discuss the platform, known as Seagull, the standards-based and cloud-first data infrastructure that feeds it, and the practical ways by which data cataloged on Seagull may be discovered and accessed.

**Bill Snodgrass**[1], Patrick Delaney[2], Greg Rose[3], Gregory Barber[4], Sonya Semanuik[5], Tavis Nimmo[6], Liza Ballantyne[1], Therese Estephan[4] and Ashley Brettell[6], [1]City of Toronto, Toronto, ON, Canada, [2]DHI Canada, Cambridge, ON, Canada, [3]WSP, Mississauga, ON, Canada, [4]Region of Peel, Brampton, ON, Canada, [5]OCWA, Mississauga,, ON, Canada, [6]Region of Durham, Whitby, ON, Canada. **Development of the Lake Ontario Hydrodynamic and Water Quality Forecasting System (LOWQFS).**

Lake Ontario is the primary source of drinking water for approximately half the population of Ontario. A proof of concept, Lake Ontario Hydrodynamic and Water Quality Forecasting System (LOWQFS) has been completed. It provides information on real-time dynamic water quality conditions and forecasting of future conditions to local municipalities (i) to respond to contaminant spills in the lake or watersheds which could reach treatment plant intakes, (ii) assess the potential impacts of new infrastructure, (iii) implement Emergency Response exercises, and (iv) assist with adapting to climate change. The LOWQFS is a significant Source Water Protection element. It represents a significant land-to-lake tool for water quality management of contaminant spills and is founded in a governance structure between Regions of Peel, Durham, and the City of Toronto, supported by Ontario and Canada. This paper discusses the development of the LOWQFS, including its data sources. The LOWQFS is a decision support system (DSS) on a web-based platform using the MIKE 3 hydrodynamic and water quality computer code. Model calibration validation exercises are summarized. The LOWQFS needs real time data from a variety of sources, including new meteorological forecasts available every 6 hours from governmant sources, year round installations of current meters, and real time monitoring of water quality(temperature, conductivity) and flow rates from influent tributaries to Lake Ontario to support the simulation of their influent plumes into the Lake Ontario Coastal Zone.

**Phoebe Jo Soldi** and Stuart Carlton, Illinois-Indiana Sea Grant/Coastal & Great Lakes Social Science Lab, Purdue University Department of Forestry & Natural Resources, West Lafayette, IN, USA. **Determining economic and social vulnerability of flooding events in Great Lakes communities.**

With the impacts of climate change increasing the frequency of flooding events, flood-prone communities in the Great Lakes must begin taking adaptive measures to increase flood resilience. The Federal Emergency Management Agency (FEMA) offers many programs to landowners in vulnerable regions to assist in protecting their investments. The Community Rating System (CRS), one of FEMA's advanced flood-assistance programs, provides discounted flood insurance for eligible communities that maintain floodplain management practices above the minimum requirements of the National Flood Insurance Program (NFIP). CRS enrollment can decrease the economic vulnerability of individuals living in floodplain communities. To explore the increased need for these incentive programs, we compiled data on CRS-enrolled communities within the Great Lakes region. We used the Social Vulnerability Index (SVI) to identify communities with high social vulnerability, which we compared across communities enrolled and not enrolled in CRS. Our results helped clarify which vulnerable communities are most at-risk from Great Lakes flooding events and are most in need of support.

**Yang Song**[1], Ayumi Fujisaki-Manome[2,3], Chris Barker[4], Dylan Righi[4], James Kessler[5], Dan Titze[5] and Jia Wang[5], [1]Cooperative Institute for Great Lakes Research, School for Environment and Sustainability, University of Michigan, Ann Arbor, MI, USA, [2]Cooperative Institute for Great Lakes Research, University of Michigan, Ann Arbor, MI, USA, [3]Climate & Space Sciences and Engineering, University of Michigan, Ann Arbor, MI, USA, [4]NOAA Office of Response and Restoration, Seattle, WA, USA, [5]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, USA. **Advancing modeling capability of oil spill transport by considering ice cover in the Great Lakes.**

The risks of oil spills in cold and icy water environments have been increasing due to intensive offshore activities and enhanced demand for energy. However, oil spill simulations under icy conditions are complex and less studied, especially in freshwaters. To advance the capability of modeling oil spill transport and fate in the Great Lakes, we conducted a modeling study using the General NOAA Operational

Modeling Environment (GNOME) and the hydrodynamic-ice model outputs from the experimental version of the NOAA's Great Lakes Operational Forecast System (GLOFS). We explored how ice affected oil spill trajectories from possible spills in Lake Erie and the Straits of Mackinac using sensitivity tests with and without ice processes in the model for the freezing, stable, and melting seasons. Preliminary results showed that: 1) Ice cover notably altered modeled oil spill trajectories in all three seasons, compared to no ice scenarios; 2) The distance between ice cover and spilled oil largely determined how strongly the oil diffusion is affected by the ice; 3) High-concentration ice prevented oil from spreading further compared with open water because it could create natural barriers and reduce surface current and diffusion. We highlight possible oil spill trajectories under various scenarios and discuss possible advancements of the model application for emergency response in freshwaters. This research is part of efforts supported by the Great Lakes Coast Guard Oil Spill Center of Expertise.

**Lisa Sonnenburg**, Parks Canada, Nipigon, ON, Canada. **Integrating cultural resources into climate change monitoring and ecological corridor planning.**

Most proposals and plans for monitoring the effects of climate change in protected and conserved areas, or the establishment of ecological corridors, focus on the physical environment and associated natural resources. Cultural resources such as archaeological sites and view sheds are not thoroughly considered during these processes, as many organizations treat natural and cultural resources as separate entities. Increasingly, cultural resource management (CRM) practitioners realize that this division is not reflective of how many Indigenous people view their relationship between culture and environment. This recognition is a direct result of the difficult work of Indigenous colleagues, partners and communities challenging long-held beliefs and practices in both cultural and natural resource management. This presentation will explore how integrating cultural resource knowledge into resource conservation plans can provide a more holistic picture of climate change effects, and ensure that cultural practices are recognized as an integral part of plans for ecological corridors. This approach is in the early phases of implementation at the Lake Superior National Marine Conservation Area, and will illustrate some of the initial practical applications of better integration of natural and cultural resource management practices.

**Scott Sowa**[1], Matthew Child[2], Marc Gaden[3], David B. Bunnell[4], Paul Drca[5], Kathleen Colin Williams[6], Roger Knight[3], Richard K Norton[7], Rachael Franks-Taylor[8], Alessandra Aponte[9] and Janette Anderson[10], [1]The Nature Conservancy, Lansing, MI, USA, [2]International Joint Commission, Windsor, ON, Canada, [3]Great Lakes Fishery Commission, Ann Arbor, MI, USA, [4]USGS Great Lakes Science Center, Ann Arbor, MI, USA, [5]Essex Region Conservation Authority, Essex, ON, Canada, [6]USEPA Office of Research and Development, Duluth, MN, USA, [7]University of Michigan, Ann Arbor, MI, USA, [8]Affiliate to NOAA Office of Coastal Management, Traverse City, MI, USA, [9]University of Waterloo, Waterloo, ON, Canada, [10]Environment and Climate Change Canada (retired), Burlington, ON, Canada. **Improving How Science Informs Policy Within an Ecosystem Management Approach.**

Science is fundamental to sound policies, particularly when it comes to implementing an Ecosystem Management Approach (EMA). We believe science can and should inform nearly all facets of an EMA, yet we recognize there are many challenges to this aspiration which is reflected by the relatively few examples such a comprehensive science-driven EMA. To help identify and better understand these challenges we used a qualitative case-study approach to compare the challenges and successes of implementing a science-driven EMA in the Laurentian Great Lakes. These case studies include improving coastal resilience, delisting of Areas of Concern, and addressing the challenges of declining offshore productivity. These case studies were selected because they provide a set of very different, yet complementary, cases for assessing the implementation of an EMA and the factors influencing the science-policy exchange that informs it. From this comparative assessment we identified a diverse set of challenges and successes. Some were systemic while others were more case-study specific. Also, emerging from this comparative assessment were

principles and enabling conditions we believe are critical to consider when establishing or improving a science-driven EMA that will be the focus of this talk.

**Elizabeth Speller**[1], **Rebecca Dolson**[2] and Namrata Shrestha[2], [1]Toronto and Region Conservation Authority, Vaughan, ON, Canada, [2]Toronto and Region Conservation Authority, Toronto, ON, Canada. **Integrated Watershed Planning, Science, Policy, and Implementation in the Greater Toronto Area.**

Integrated watershed planning and management requires a robust understanding of scientific and local knowledge on watershed components and strong collaboration between various levels of government, stakeholders, public, and Indigenous communities. This helps identify priorities and measures to protect, enhance, and restore watershed conditions for long term sustainability and resilience. Using specific examples, this presentation will outline the watershed planning approach taken in the Greater Toronto Area by Toronto and Region Conservation Authority and its municipal partners to ensure watershed health and community well-being. First, it will highlight key results of technical components analyzed to support watershed planning and management including terrestrial and aquatic ecosystems, water quality, and natural hazards. These components were evaluated to understand existing conditions and potential future conditions under different land use and climate change scenarios. Second, it will show how these components were translated by TRCA and partners to co-develop a shared implementation framework and to facilitate implementation of priority management actions. Lastly, this presentation will discuss the importance of this work to improve our understanding of land to lake connections and to benefit Lake Ontario health.

**Katie Stammler**[1] and Alice Grgicak-Mannion[2], [1]Essex Region Conservation Authority, Amherstburg, ON, Canada, [2]University of Windsor, Windsor, ON, Canada. **Expanding greenhouse sector in Essex County, ON contributes to downstream water quality degradation.**

The Great Lakes Water Quality Agreement named the Leamington Tributaries as a priority watershed for phosphorus load reduction to mitigate Harmful Algal Blooms in Lake Erie. These are actually several relatively small, hydrologically distinct watersheds in the municipalities of Leamington and Kingsville in Essex County, Ontario, and they are heavily influenced by greenhouse agriculture. In 2012, the Essex Region Conservation Authority began monitoring these watersheds biweekly year-round and in 2016 began event sampling with ISCO autosamplers in three watersheds. Now, with a decade of data, we explore long term trends and comparisons in nutrient concentration and load between greenhouse and non-greenhouse influenced streams. In addition, students at the University of Windsor digitized the footprint of greenhouses from aerial photography between 2000 and 2020. In total, the greenhouse footprint has more than tripled over this 20-year period, with many more greenhouses installed after our analysis. In the study watersheds, the greenhouse footprint increased between 4 and 20%. Year over year, nutrient concentrations are significantly, and strikingly higher in greenhouse streams than non-greenhouse streams. Perhaps most telling is the increase in nutrient concentration in a watershed that went from 0% to >20% of the watershed in greenhouse agriculture, where all structures are newly built. With greenhouse agriculture continuing to expand in this area, and elsewhere in the Great Lakes Basin, it is essential that we take heed of this canary in the coal mine.

**Isabelle Staph**[1], Stuart Carlton[2], Rebecca Nixon[3] and Zhao Ma[4], [1]Coastal & Great Lake Social Science Lab, Purdue University Department of Forestry & Natural Resources, West Lafayette, IN, USA, [2]Illinois-Indiana Sea Grant/Coastal & Great Lakes Social Science Lab, Purdue University Department of Forestry & Natural Resources, West Lafayette, IN, USA, [3]Geography, University of Delaware, Newark, DE, USA, [4]Purdue University Department of Forestry and Natural Resources, West Lafayette, IN, USA. **Public participation in restoration of the Grand Calumet River Area of Concern.**

Many communities in the Great Lakes region are negatively impacted by degraded waterways and waterbodies in their area. In the 1980s, the US and Canada designed 43 degraded shorelines as Areas of Concern (AOCs). Over the past several decades, significant restoration and remediation efforts have taken place with the goal to improve restore and remediate these waters. However, these impacted communities continue to face numerous environmental and economic obstacles in their restoration, remediation, and revitalization efforts. One of these areas is the Grand Calumet River, a waterway located in northwest Indiana along Lake Michigan. This research focuses on examining community participation in the restoration, remediation, and revitalization processes in the Grand Calumet River AOC with a focus on the perspectives of environmental and planning professionals involved in the restoration and revitalization work. Our project analyzes data from interviews with leaders in Grand Calumet River AOC interview data and Citizens Advisory for Remediation of the Environment meeting summaries to assess public participation in these efforts. Our results shed light on the importance of representation and transparency in increasing public participation in AOCs.

**Marek Stastna**[1] and Andrew Grace[2], [1]University of Waterloo, Waterloo, ON, Canada, [2]Notre Dame University, South Bend, IN, USA. **Simulating late winter lake dynamics: lessons from process studies.**

In later winter many lakes in Canada and the northern United States remain ice covered but experience significant radiative forcing. The ice cover cuts of the input of mechanical energy from the wind, but a subset of solar radiation penetrates the ice cover and modifies the buoyancy profile in the underlying water column. I will report on several recent idealized process studies (i.e. direct numerical simulations) which probe the dynamics in this regime using well-studied theoretical constructs (e.g. gravity currents, hydrodynamic instabilities). These demonstrate that standard paradigms from the ice-free season do not immediately transfer to the late winter. In particular, the nonlinearity of the equation of state of freshwater drives profound changes in dynamics, modifies the rate of mixing and impacts standard parametrizations used in lake scale models.

**Bob Sterner**[1], Byron Steinman[1] and Brenda Lafrancois[2], [1]University of Minnesota Duluth, Duluth, MN, USA, [2]National Park Service, Ashland, WI, USA. **Vanishing winter underlies summer cyanobacteria blooms in Earth's largest lake.**

Oligotrophic Lake Superior has experienced nearshore cyanobacterial blooms in six of the past eleven years, an emerging and unexpected ecological condition that has generated much public concern. Here we show that temperature in the preceding winter, and the effect this has on water temperature mainly early in the growing season, is the main driver of cyanobacterial bloom likelihood. Air temperatures were very similar in bloom vs. non-bloom years during the actual bloom season. However, winters preceding bloom summers had air temperatures that averaged significantly higher (~ 4 ºC) than winters preceding non-bloom summers. Winter air temperatures are warming faster than summer temperatures in the Great Lakes region, and many questions have been raised about what impact moderating winter conditions might have. For water temperature, statistically significant differences between bloom and non-bloom years were most frequently observed from January through June. Bloom years begin with small but significantly warmer temperatures in the winter, and the magnitude of those differences grows into summer. Our results provide one specific example and indicate a lag in cause and effect, that warming winter air temperatures ultimately result in the formation of cyanobacterial blooms in the following summer. The results help to explain how algal blooms can arise even in low-nutrient environments like Lake Superior and provide evidence for ecological impacts of so-called "vanishing winter".

**Claire M Stevens**[1], Carolina Koebel[1], Sophie Crevecoeur[2], Nicole D. Wagner[3], Arthur Zastepa[4], Paul C Frost[1], Nolan J. T. Pearce[1] and Marguerite A Xenopoulos[1], [1]Trent University, Peterborough, ON, Canada, [2]Water Science and Technology Directorate, Environment and Climate Change Canada, Burlington, ON,

Canada, [3]Oakland University, Rochester, MI, USA, [4]Environment and Climate Change Canada, Burlington, ON, Canada. **The Role of N:P Stoichiometry on Harmful Algal Blooms in the Western Basin of Lake Erie.**

The western basin of Lake Erie experiences dense, spatially expansive, and potentially toxin-producing harmful algal blooms (HABs), which can be so severe that intakes for municipal drinking water systems must be temporarily shut down. While it is well understood that excess phosphate can lead to blooms, there is still much unknown about how the ratio of nitrogen (N) to phosphorus (P) supply affects natural algae communities, as well as expression of toxin-producing *mcy* genes in HABs. It is currently suggested that N availability can drive toxin production, but a strong consensus has yet to be reached. Here, we performed *in situ* bioassay experiments to test the influence of variable supply ratios of N:P on the growth and toxicity of algae in the Pigeon Bay area. Nitrogen spikes were added to bioassay bottles while P was kept constant, and bottles were incubated in Pigeon Bay for either 24 or 72 hours. N:P ratios ranged from 4:1 to 124:1. Our preliminary results suggest that microcystin toxin concentration increased with increasing N:P ratios for the 72 hour, but not the 24 hour incubation period. These findings emphasize that a full understanding of N:P stoichiometry is needed to manage algal toxicity in Lake Erie.

**Jordyn T Stoll**[1], Ryan Wagner[2], Dennis Otieno[3], Sharon Miniga[2], Sharon Adhiambo[2], Hannah Kahoro[2], Tony Nyabayo[2], Bruno Odhiambo[2], Zadock Ochieng' Omach[3], Hillary Moraa[2], Harriet Atieno Okeyo[4], Argwings Owino[2], George Basweti[2], Julia Akinyi Obuya[2], Brittany N. Zepernick[5], Kaela Elizabeth Natwora[6], Winnie Owoko[2], Katelyn Brown[2], Katelyn Barker[2], Emily Marcella Varga[2], Max Beal[2], Samantha Mohney[2], Davide Lomeo[2], Aidan Byrne[2], Emma Tebbs[7], James Achiya[2], Ken G Drouillard[8], Robert Michael McKay[8], Lewis Sitoki[9], Ted J Lawrence[10], Kefa Otiso[11], David M Costello[12] and George S. Bullerjahn[11], [1]Kent State University, Vermilion, OH, USA, [2]NSF-IRES Lake Victoria Research Consortium, Bowling Green, OH, USA, [3]Kenya Marine and Fisheries Research Institute, Kisumu, Kenya, [4]Fish Biology Research Intern, Kisumu, Kenya, [5]University of Tennessee, Knoxville, TN, USA, [6]University of Minnesota - Duluth, Two Harbors, MN, USA, [7]King's College London, London, United Kingdom, [8]Great Lakes Institute for Environmental Research, University of Windsor, Windsor, ON, Canada, [9]Technical University of Kenya, Nairobi, Kenya, [10]International Institute for Sustainable Development, Winnipeg, MB, Canada, [11]Bowling Green State University, Bowling Green, OH, USA, [12]Department of Biological Sciences, Kent State University, Kent, OH, USA. **Nutrient limitation in the cyanobacteria harmful algal bloom (cHAB) riddled Nyanza Gulf, Lake Victoria, Kenya.**

Cyanobacteria harmful algal blooms (cHABs) are increasing in frequency and extent globally and their growth is known to be driven by eutrophication. Lake Victoria has year-round blooms of the cosmopolitan cyanobacteria *Microcystis aeruginosa*, which can produce microcystins that are dangerous at µg/L concentrations and endanger fisheries by bloom decomposition inducing hypolimnion anoxia. Lake Victoria is shared by Kenya, Tanzania, and Uganda and supports the livelihood of more than 73 million people. Using bottle incubations, we assessed the effects of nutrient type (nitrogen (N), phosphorus (P), micronutrients) and form (urea, nitrate, ammonium; phosphate, G6P) on phytoplankton growth and microcystin production across four sites in the Nyanza Gulf of Lake Victoria during June-July 2022. Results suggest primary N limitation followed by serial P and micronutrient colimitation across the gulf. Nitrate addition induced 2-3 times more growth than other N forms at one site, while urea, ammonium and nitrate had a similar positive effect on growth at the remaining three sites. Micronutrient and P effects were spatially variable, but increased growth under micronutrient enrichment suggest that organic nutrient recycling may be limited by micronutrients in parts of the gulf. Though blooms of *Microcystis aeruginosa* were common, microcystin was only detected (>2 ug/L) at one site (Homa Bay). Our findings will inform best management practices for nutrient management in Lake Victoria's watershed to reduce cHABs in this highly relied upon natural resource.

**Noelle Gadfly Stratton**[1], Nicholas E. Mandrak[2] and Nicole Klenk[1], [1]University of Toronto Scarborough, Toronto, ON, Canada, [2]Department of Physical and Environmental Sciences, University of Toronto Scarborough, Toronto, ON, Canada. **The role of the media in communicating about Great Lakes aquatic invasive species.**

Effective invasive species communication plays an important role in enabling stakeholders and publics to better recognize aquatic invasive species (AIS) and understand how they can help management efforts. Some AIS stories are shared in the media, with governments and managers also relying on their own social media accounts to share information with a wide audience. Using surveys, interviews, and focus groups, our research explored in-depth how academics, decision-makers, and publics in the Great Lakes region felt the media contributed to their understanding of AIS. Participants described what form of media they considered most important and their perceptions of what the role of the media should be in AIS outreach, their experiences with how the media tend to portray these AIS, and recommendations for improvement. This research outlines the importance of the media in sharing AIS information, but also the limitations if those reporting the stories are not themselves adequately informed about AIS issues.

**Pamela Strong**, Chandler Eves, Kaitlyn D Read, David Lembcke, Eavan M. O'Connor and Bill Thompson, Lake Simcoe Region Conservation Authority, Newmarket, ON, Canada. **A review of management actions by the Lake Simcoe Region Conservation Authority to reduce salt use.**

Monitoring through the Provincial Water Quality Monitoring Network and Lake Simcoe Protection Plan has shown increasing chloride concentrations in the Lake Simcoe watershed, with potential impacts to aquatic life, built infrastructure, and drinking water sources. Much of this increase is due to the application of winter salt to melt snow and ice, with roads and parking lots being major contributors. In recognition of this challenging issue, the Lake Simcoe Region Conservation Authority has undertaken several management activities aimed at better understanding salt use and what can be done to achieve reductions. Management actions have included the development of parking lot design guidelines for salt reduction and advocating for their inclusion in municipal planning documents; the completion of two case studies, examining 1) the implications of a municipality changing its practices, and 2) the use of best practices by a contractor on a commercial site; a working group of watershed municipalities aimed at sharing experiences and new technologies; and a Freshwater Roundtable of practitioners, commercial property owners and managers, and other stakeholders was convened to explore legal avenues to enable practitioners to apply less salt on commercial properties by addressing liability concerns. This presentation will detail these activities, discussing the successes and challenges of each.

**Rochelle Sturtevant**[1], Ashley K Elgin[2], El Lower[3] and Joris Van Zeghbroek[4], [1]NOAA/GLERL - GLANSIS, Michigan Sea Grant, Ann Arbor, MI, USA, [2]NOAA GLERL, Muskegon, MI, USA, [3]GLANSIS, Michigan Sea Grant, Ann Arbor, MI, USA, [4]Michigan Sea Grant, Ann Arbor, MI, USA. **GLANSIS: Verified data for non-native species.**

The Great Lakes Aquatic Nonindigenous Species Information System (GLANSIS - https://www.glerl.noaa.gov/glansis/) is a NOAA-led, GLRI-funded interagency effort to provide open access to the best available information on non-native species in the Great Lakes. The GLANSIS core functions as a regional node of the USGS Nonindigenous Aquatic Species database (NAS - https://nas.er.usgs.gov/), with additional value-added features and tools. GLANSIS provides access to full species bibliographies, distribution data, impact assessment and risk assessments for each of the nonindigenous species overwintering and reproducing below the ordinary high water mark of the Great Lakes (193 species), for each of the range expansion and cryptogenic species within the Great Lakes (27), and for species identified as posing a threat of becoming established (92). The GLANSIS Risk Clearinghouse provides access to information on more than 2000 additional species that have been evaluated by regional partners as well as to federal, state, provincial and tribal regulations governing these species. The GLANSIS Map Explorer provides access to habitat suitability maps published by regional

partners and interfaces with regional habitat layers provided by partners at the Great Lakes Aquatic Habitat Framework (GLAHF - https://www.glahf.org/) allowing easy exploration of AIS distributions in context of habitat. Individually and when used together, the data and tools provided by GLANSIS are a powerful, publicly-accessible information resource for Great Lakes ecology.

**Rochelle Sturtevant**[1], Connor Shelly[2], Ashley K Elgin[3], El Lower[4] and Joris Van Zeghbroek[2], [1]NOAA/GLERL - GLANSIS, Michigan Sea Grant, Ann Arbor, MI, USA, [2]Michigan Sea Grant, Ann Arbor, MI, USA, [3]NOAA GLERL, Muskegon, MI, USA, [4]GLANSIS, Michigan Sea Grant, Ann Arbor, MI, USA. **Leveraging historic AIS distribution data to predict future patterns of spread.**

Prediction of future spread is critical in determining where to prioritize early detection efforts; examination of historic patterns of movement and current distributions may provide insight into future species movements. The Great Lakes Aquatic Nonindigenous Species Information System (GLANSIS - https://www.glerl.noaa.gov/glansis/) includes more than 90,000 historic records spanning 2 centuries which reflect the full taxonomic diversity as well as range of pathways of introduction and spread of nonindigenous species in the Laurentian Great Lakes. Our project examines 2 methods for potential prediction of future distributions based on historic patterns for a key subset of these species. A 'nearest neighbor' approach looks at adjacent watersheds (HUC8) as high risk areas for future spread. A habitat-based approach using Aquatic Ecological Units provided by the Great Lakes Aquatic Habitat Framework (GLAHF - https://www.glahf.org/) identifies uninvaded geographic regions of similar ecological type to already invaded habitats as high risk for future spread. Strengths and limitations of each type of analysis are outlined as well as potential synergies.

**Zhenming Su**, Institute for Fisheries Research, Michigan Department of Natural Resources, Ann Arbor, MI, USA. **Evaluation of Bus-route and Aerial-access Methods for Great Lakes Recreational Fisheries Surveys.**

Management agencies in the Great Lakes areas invest heavily in creel surveys for the purpose of monitoring and managing their recreational fisheries. Costly airplane boat counting methods are often utilized to survey expansive and complex recreational fishing areas in the Great Lakes. Using field comparative surveys and Monte Carlo simulation techniques, bus-route and aerial-access creel survey methods were evaluated and compared for the Michigan Lake Erie recreational fisheries. The two methods yielded comparable estimates of fishing effort and catch for the 2021 field comparative study. However, aerial survey estimates of fishing effort were found by simulations to be sensitive to the expansion factor used in the estimation of daily fishing effort. Simulations allowed for the identification of appropriate values of the expansion factor that led to least biased effort estimates. The bus-route method was found using simulations to be statistical sound and cost-effective compared to the traditional aerial-access method. Therefore, a large cost savings could be realized from employing the bus-route method for these areas instead of the aerial-access creel survey method. However, the need of tallying all returning parties at the access sites in the bus-route survey might limit the clerk's flexibility to collect biological and other data. Cameras may be used to obtain daylong counts of angler parties returning from a fishing trip in an access type of survey and free the clerks from the constant presence at the access sites.

**Amanda K. Suchy**, Corrin Logan, Anna M Harrison and Donald G. Uzarski, Central Michigan University, Mount Pleasant, MI, USA. **Patterns and drivers of microplastics in Great Lakes coastal wetlands.**

Microplastics- a pervasive and persistent pollutant- have been found in nearly all environments globally and can affect various ecological functions and harm wildlife. However, the transport and retention of microplastics, particularly in freshwater ecosystems, is not well understood. Coastal wetlands of the Great Lakes provide many important ecological functions from critical wildlife habitat to reducing nutrient pollution. However, dense vegetation and low water velocity typical of coastal wetlands, paired with inputs

from both terrestrial and open water environments, generate conditions prime for microplastic deposition. We examined microplastic concentrations in the sediments of 30 Great Lakes coastal wetlands of different hydrogeomorphic classes and spanning a range of disturbance gradients. We found biophysical characteristics were more predictive of microplastic concentrations than indicators of anthropogenic disturbance. Microplastic concentrations were significantly higher in barrier protect wetlands (2423 particles/kg dry soil) with lowest concentrations in lacustrine wetlands (157 particles/kg dry soil). Additionally, the wetlands with the highest microplastic concentrations were dominated by species of *Typha* or *Phragmites*. Interestingly, we found no relationships with landcover- a frequent predictor of microplastics in freshwater environments. These results highlight the need to better understand source, sink, and flux dynamics of microplastics in freshwater environments.

**Madison Summers**[1] and Xiaozhen Mou[2], [1]Kent State University, Kent, OH, USA, [2]Kent State University, Department of Biological Sciences, Kent, OH, USA. **Role of Microbial Community in Removing Cyanotoxins During Drinking Water Filtration.**

Cyanobacterial harmful algal blooms (CyanoHABs) are a common occurrence throughout the United States and are especially frequent in the surface waters of the Great Lakes region. Many drinking water plants draw source water from CyanoHAB impacted surface water, posing concerns for cyanotoxin contamination. This research project aimed to study the potential role of biofiltration during drinking water treatment in removing cyanotoxins. Lab-scale filtration columns were set up to mimic filters in two local drinking water plants. Six of these columns were fed with source water from each plant for 4 wks (TRT) to establish in-situ microbial communities, while the other six were fed with sterile artificial freshwater (CTR). Afterwards, individual cyanotoxins or mixtures (i.e. microcystin-LR, saxitoxin, and anatoxin-A) were spiked to each column to study the removal efficiency of toxins by column filtration. The filter media were also sampled at the end of the experiment (4 wks) and used for bacterial culturing by plate streaking and liquid media enrichments. Taxonomic composition of cultured bacteria were obtained by DNA extraction, PCR and sequencing of the 16S rRNA gene V4 region. We found that addition of anthracite in sand filters significantly increased the removal efficiency of all toxins. Anatoxin-a was removed at a greater rate when it was present alone than in a mixture while both saxitoxin and microcystin-LR showed no significance. Lacking in situ microbial communities did not significantly alter toxin removal efficiency between the CTR and TRT columns.

**Laura L Swatridge**[1], Leon Boegman[2], Shi liang Shan[3] and Ryan Mulligan[1], [1]Queen's University, Kingston, ON, Canada, [2]Environmental Fluid Dynamics Laboratory, Department of Civil Engineering, Queen's University, Kingston, ON, Canada, [3]Department of Physics and Space Science, Royal Military College of Canada, Kingston, Canada. **Real-Time and Forecast Modelling of Storm Surges and Surface Waves in Lake Ontario.**

On December 1, 2022, Lake Ontario experienced a strong storm event (southwesterly winds > 20 m/s), generating large waves > 4.4 m and a storm surge > 0.25 m along the northeastern shoreline. In this work, results from a real-time and forecast model applied to Lake Ontario during this event are examined. The operational forecast system uses a two-dimensional coupled Delft3d-SWAN model to simulate mean currents and surface waves, driven by wind and pressure fields from Environment Canada's High Resolution Deterministic Prediction System (HRDPS). Forecasts are updated automatically every 6 hours, generating model predictions of water levels out to 48 hrs, which are posted online (https://coastlines.engineering.queensu.ca/lake-ontario/). The forecasted results were validated with observed data available at 9 real-time water level gauges and 1 wave buoy. Results show good agreement between observed and modelled data (RMSE = 0.02 m; $r^2$ = 0.90) with a maximum error between observed and predicted storm surge magnitude and peak wave height of 0.07 m and 0.10 m, respectively. Model results are compared to an existing Great Lakes forecast model (Great Lakes Coastal Forecasting System;

GLCFS) which uses a higher resolution grid and has a relatively high computation demand compared to the present work. The results show the two forecasting systems to yield comparable results.

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**Xiaozhuo Tang**[1], Charlie Loewen[2] and Donald Jackson[1], [1]University of Toronto, Toronto, ON, Canada, [2]University of Iowa, Iowa, USA. **Zooplankton composition and water quality in 50 stormwater ponds, Ontario.**

We sampled zooplankton species and assessed water quality from 50 stormwater management ponds in Brampton, Ontario during summer 2022. These ponds are engineered systems that have filled with surface runoff and have been recently colonized by aquatic taxa. These small ponds provide an excellent opportunity to study the mechanisms underlying the formation and dynamics of populations and communities in new habitats, as well as the role of environmental filters in determining species composition. We investigate the association of environment stressors (e.g., salinity, anoxia, predators) with the composition of zooplankton, primarily Crustacea, in the ponds. We use multivariate statistical analysis to determine the relative importance of environments stressors such as elevated salinity from road salt and the presence of fish, that influence zooplankton composition across these stormwater ponds. Relationships of pond design, landscape features, and the association of water quality with zooplankton composition provide insight regarding colonization dynamics, as well as how pond design and operation may influence community composition in these important aquatic habitats in urban ecosystems.

**Wilson Tarpey** and Todd R Miller, University of Wisconsin - Milwaukee, Milwaukee, WI, USA. **Low Cost "Open Source" Fluorometry Hardware.**

Fluorometers can be used for monitoring of algal biomass via fluorescent photosynthetic pigments such as chlorophyll and phycocyanin. Our open source fluorometry hardware allows a user to embed an excitation-fluorescence circuit into any project, utilizing an Adafruit Adalogger (SAMD21) to give many formats of data output such as UART, SDI-12 and analog voltage, storing calibration offsets on board. Integrated data logging on an SD card allows simple deployment, or a redundancy to ensure data integrity during deployments. Accepting from 6-30v, it can also be fit into many existing systems. Excitation LEDs, filters and emission filters can be swapped for almost any analyte. The excitation circuitry may be encoded to pulse different waveforms, speeds, duty cycles and brightness for many different experiments. High precision Analog-to-Digital converter, ADS1115, gives 16 bits of precision and 5 different gain settings up to 16x. Onboard temperature sensor (DS18B20) allows point of measurement temperature offsets

**Courtney Taylor**[1] and Erin S. Dunlop[2], [1]Trent University, Peterborough, ON, Canada, [2]Ontario MNRF, Trent University, Peterborough, ON, Canada. **Regional diet and isotopic niche of lake whitefish and lake trout following a regime shift in Lake Huron.**

Lake Huron's food web has experienced drastic changes in response to multiple stressors. Broad shifts include declines in offshore productivity, and a decrease in the trophic transfer efficiency, leading to concerns about food supply for fish. Lake whitefish are a species of particular concern given substantial declines in abundance, growth, and recruitment since the 1990's. Another species of interest is lake trout, the historic top predator whose populations are recovering following decades of decline. Concerns have been raised that recovering lake trout populations are competing with or consuming lake whitefish. Here, we aim to describe the diets and isotopic niches of lake trout and lake whitefish given concerns that lower ecosystem productivity has reduced the prey resources available to these important species. We found that while niche overlap is overall low between the two species, it does vary by region, being lowest in the main basin and highest in Georgian Bay. Lake whitefish have larger niches than lake trout, with δ13C values of

lake whitefish indicating a range of nearshore and pelagic energy sources. Lake whitefish niche is broadest in the North Channel, where the diet is more diverse and contains fewer invasive species. The niche size for lake trout is narrowest in the northern main basin, where pelagic rainbow smelt are the primary food source. Our isotope analyses reflect the high regional diversity of energy sources found in the diet study, and little evidence of overlapping resource use between lake trout and lake whitefish.

**Lindsay Taylor**[1,2], **Sean Parkinson**[1,3] and Rachel Braithwaite[1], [1]St. Catharines Downtown Association, St. Catharines, ON, Canada, [2]Niagara College Canada, Ecosystem Restoration, Niagara-on-the-Lake, ON, Canada, [3]Fleming College, Urban Forestry Micro-Credential Program, Lindsay, ON, Canada. **The role of applied science in decision making for urban forest management in the great lakes basin.**

Nestled between Lake Erie and Lake Ontario lies a small downtown business center in St. Catharines. The Twelve Mile Creek, which thunders past the southwest bend of the downtown core on its way to Lake Ontario, is bordered by a natural heritage zone that is designated a Niagara Natural Environmental Screening Layer (NNSEL) and a regulated floodplain by the Niagara Peninsula Conservation Authority (NPCA). As development pressures grow, it is imperative to protect this water and its surrounding lands. According to the Provincial P2G Growth Plan, by 2041 the St. Catharines Downtown population is expected to increase by 30%. As a proactive strategy to managing the urban forest downtown, the St. Catharines Downtown Association (SCDA) in collaboration with Niagara College has launched an inhouse census & analysis on the state of Urban Street Trees (USTs) within the Business Improvement Area (BIA). This research demonstrated that a diverse and mature UST population contributes to disease resiliency, tree equity, and overall community health. UST infrastructure also provides stormwater storage & filtration, carbon sequestration, and the development of urban wildlife habitat, while reducing the stressors associated with the urban heat island effect. Findings from this report also demonstrate fiscal opportunities when USTs are effectively managed as capital assets. A series of recommendations from this report will be brought forward to the City of St. Catharines in the Spring of 2023. For more information visit: mydowntown.ca/urban-street-trees

**Stephen M Techtmann**, Isaac Bigcraft and Abigail Kuntzleman, Michigan Technological University, Houghton, MI, USA. **Oil Biodegradation and Prediction of the Presence of Oil in the Great Lakes.**

The fate of oil in the Great Lakes is in part determined by the rate of oil biodegradation. A wide array of microorganisms degrade components of oil. However, the microbial response to oil in the Great Lakes is understudied. To better understand the potential for oil biodegradation in the Great Lakes, we have performed a series of microcosm experiments. Surface water was collected from seven sites across the Great Lakes. Microcosms were amended with crude and refined oil. The microbial community composition and the rates of respiration were measured for these microcosms across five weeks. Our results indicate that the amendment with oil shifts the microbial community composition with a diverse set of taxa enriched in oil-amended conditions. Similar microcosms were set up from the Straits of Mackinac with samples from three seasons. This work demonstrated a distinct response in the microbial community to oil seasonally as well as decreased biodegradation of oil under lower temperature conditions. We have constructed machine learning models to use microbial community composition as tools to predict the presence and type of oil in samples from the Great Lakes. These models accurately predict the presence of oil using as few as 10 indicator taxa and are able to differentiate between the type of released oils. Our work highlights the potential for oil degrading bacteria to play a role in determining the fate of oil in the Great Lakes as well as serve as a potential tool for monitoring contamination in the Great Lakes.

**Alana Tedeschi**[1] and **Jacqueline Vinden**[2], [1]McMaster University, Hamilton, ON, Canada, [2]Biology, McMaster University, Hamilton, ON, Canada. **Degraded streams to crystal clear waters: Developing community-science methods for nutrient monitoring.**

Eutrophication from excessive phosphorus (P) is a growing global problem, and the Great Lakes Basin is no exception. Consistent water-quality data are required for management and informed decision making for phosphorus mitigation; however, many jurisdictions currently lack the capacity to sustain long-term monitoring programs. We developed feasible bioindicators for measuring phosphorus concentration using benthic algae growth over a range of aquatic ecosystems in the Great Lakes. With accessible materials, community volunteers can quantify benthic algal growth in their water bodies, and make inferences about excess P availability over two-week periods. Here, we will highlight how our initiatives have increased the spatiotemporal reach of water-quality monitoring in local communities from degraded streams in Southern Ontario to the pristine nearshore waters of Georgian Bay.

**Kristin TePas**[1], Shari Insley[2], Amy Boros[3] and Melissa Kowalski[4], [1]University of Illinois, IL-IN Sea Grant, Chicago, IL, USA, [2]Pine Intermediate School, North Olmsted, OH, USA, [3]Hull Prairie Intermediate School, Perrysburg, OH, USA, [4]Put-in-Bay Schools, Put-in-Bay, OH, USA. **Shipboard Experience for Educators Spurs New Ideas in the Classroom.**

The Shipboard Science Workshop aboard the EPA's R/V *Lake Guardian* is a one-of-a-kind opportunity for educators to gain an intimate understanding of the Great Lakes. The annual cruise is organized by Sea Grant's Center for Great Lakes Literacy. They bring together 15 educators from across the basin to work side-by-side with scientists for the week, collecting and working up samples, while also learning about Great Lakes curricular resources. Educators are then tasked with infusing the Great Lakes into their curriculum once they return to their classrooms. Examples of how educators transferred the knowledge and experience back in their educational settings will be shared by three alumnae "Guardianites." They will share their experiences along with some exciting activities that can be used to engage students in learning about issues affecting our Great Lakes.

**Sebastian Theis**[1,2], Lyndsay Cartwright[3], Angela Wallace[1], Brynn Coey[1], Mark Poesch[2], Rick Portiss[1] and Jonathan Ruppert[3,4], [1]Toronto and Region Conservation Authority (TRCA), Vaughan, ON, Canada, [2]University of Alberta, Edmonton, AB, Canada, [3]Toronto and Region Conservation Authority, Vaughan, ON, Canada, [4]Department of Ecology and Evolutionary Biology, University of Toronto, Toronto, ON, Canada. **Fish community changes along the Toronto Waterfront over the past decades based on boat electrofishing surveys.**

Aquatic littoral habitat in the Greater Toronto Area has been exposed to a multitude of environmental and anthropogenic stressors ranging from increased urbanization and shoreline development to being exposed to aquatic invasive species. Habitat degradation led to the Toronto Waterfront being listed as an Area of Concern in 1987. Extensive shoreline and riparian habitat restoration has been implemented by the city as part of the Toronto and Region Remedial Action Plan in conjunction with different ministries and NGOs. The overall objective of these restoration efforts is to increase fish, bird, and wildlife habitat. A key aspect of current fish habitat restoration efforts, monitored by the Toronto and Region Conservation Authority, is to account for long-term community changes within the target ecosystem to better understand changes on a larger spatial scale. This waterfront-wide evaluation allows us to detect overall changes along the waterfront and can be beneficial to understand community changes happening at an ecosystem level when implementing and monitoring restoration projects.

**Bill Thompson**, Lake Simcoe Region Conservation Authority, Newmarket, ON, Canada. **Land use change in the Lake Simcoe watershed: 2003-2018.**

Land use has substantial impact on watershed function, including impacts on stream flow, nutrient loading, and biodiversity. Lake Simcoe Region Conservation Authority recently undertook a project to develop a series of detailed land cover maps for the Lake Simcoe watershed on a five-year cycle, starting in 2003. As expected, population increase in the watershed has led to an increase in impervious cover. Less

expected was an increase in natural heritage cover, resulting (in part) from recent shifts in the agricultural sector. New approaches to land use planning policy or program development may be necessary to ensure the natural heritage increases are not transient, and to manage future impacts of impervious cover as development in the watershed continues.

**Bridget R. Thornburg**[1], Paige J. Penningroth[1], Matthew J. Hudson[1], Matthew J. Cooper[2] and Peter S. Levi[1], [1]Mary Griggs Burke Center for Freshwater Innovation, Northland College, Ashland, WI, USA, [2]Institute for Great Lakes Research, Central Michigan University, Mount Pleasant, MI, USA. **Influence of episodic events on nearshore water quality in Lake Superior's Chequamegon Bay.**

Chequamegon Bay (CB) is an ideal location to study the influence of climate change on nearshore water quality as one of the warmest, shallowest, and most southerly bays in Lake Superior. Since 2014, we have conducted an integrated sampling program at ~12 stations throughout CB, collecting semi-monthly water chemistry profiles and field samples to quantify phosphorus, chlorophyll, and suspended sediment concentrations. Furthermore, we have maintained a series of continuous stream discharge stations to estimate suspended sediment and phosphorus loading to CB. Several major storm events occurred during our study period, which provide opportunities to examine the role of climate-change-driven events on spatial and temporal trends in nearshore water quality. Our results indicated that phosphorus and sediment concentrations in CB were highly influenced by episodic precipitation events and the associated tributary runoff. However, phosphorus and chlorophyll were not tightly coupled, likely due to low light availability and limited bioavailability of sediment-bound phosphorus. Our analysis of the nine-year data set suggests that episodic events contribute significant pulses of sediment and nutrients to nearshore waters of Lake Superior, though the biological response may be dictated by site-specific conditions.

**Simion G. Tolnai** and Mark Anderson, Grand River Conservation Authority, Cambridge, ON, Canada. **Improving the Quality of the Grand River by Optimizing Wastewater Treatment.**

The Grand River watershed is located in southwestern Ontario and has a growing urban population. There are thirty municipal wastewater treatment plants (WWTPs) that discharge their treated effluent into the Grand River or its tributaries. Since 2010, the Grand River Conservation Authority has been collaborating with municipal partners and the Ministry of the Environment, Conservation and Parks to develop and implement a Watershed-wide Wastewater Optimization Program (WWOP). The vision of the WWOP is to improve water quality in the Grand River by using data-based decision-making at all levels to fully tap the capacity of existing infrastructure and people to produce high quality, economical effluent. Annual reports on effluent quality and plant loading for WWTPs in the Grand River watershed have been prepared since 2012. Annual data is used to evaluate the success of the program and track WWTP impacts on the Grand River. Despite an increase in population, Total Phosphorus and Total Ammonia Nitrogen loadings to the Grand River have decreased by 38% and 93%, respectively since 2012. These improvements in water quality of the Grand River can be attributed to recent WWTP upgrades and optimization efforts. This paper summarizes the WWOP activities, success factors and challenges.

**Peter Torma**[1,2], Gabriella Lükő[1] and Janos Sajti[3], [1]National Laboratory for Water Science and Security, Budapest University of Technology and Economics, Faculty of Civil Engineering, Department of Hydraulic and Water Resources Engineering, Budapest, Hungary, [2]ELKH-SZTE Research Group for Photoacoustic Monitoring of Environmental Processes, Szeged, Hungary, [3]Budapest University of Technology and Economics, Faculty of Civil Engineering, Department of Hydraulic and Water Resources Engineering, Budapest, Hungary. **Exploring the seasonality of the latent heat flux transfer coefficient over lakes by eddy-covariance measurements.**

Evaporation plays crucial roles both in the water and the energy balance of lakes. In lake modeling, the estimation of the latent (evaporative) heat flux at the air-water interface primarily relies on the Monin-

Obukhov similarity theory (MOST); but in practice, it is simplified to a bulk method which employs a transfer coefficient, referred to as Dalton number ($C_q$). The MOST-based eddy-covariance (EC) technique is still the most accurate method to measure turbulent heat fluxes directly, from which $C_q$ can be derived. $C_q$ is considered a constant or as a wind speed-dependent function in most cases. Its value varies from lake to lake with relatively high uncertainty. Our measurements have revealed that $C_q$ has an apparent seasonal variation in Lake Balaton together with the roughness length of latent heat. Therefore, we collected EC data from several lakes with different characteristics, considering location, climate, and morphology, where measurements have been carried out over a sufficiently long time to explore seasonality. $C_q$ was derived on a monthly scale, and its inter-annual variability was detected for many lakes with different magnitudes and characteristics. Linear regression and hysteresis loop analysis revealed that the variation of $C_q$ can be linked to the energy storage of the lake. Consequently, the surface-to-volume ratio of the lake may have a significant impact. Finally, we demonstrate the effect of the seasonal variation of $C_q$ in lake temperature modeling for Lake Balaton as a study site.

**Sebestyen Torok**[1] and Péter Torma[2], [1]Dept. of Hydraulic and Water Resources Engineering, Budapest University of Technology and Economics, Budapest, Hungary, [2]National Laboratory for Water Science and Security, Budapest University of Technology and Economics, Faculty of Civil Engineering, Department of Hydraulic and Water Resources Engineering, Budapest, Hungary. **Analyzing the thermal stratification of a large polymictic lake in the light of climate change.**

With changing climate, internal lake processes such as stratification periods and intensities will also change, causing biological processes to become more unpredictable. This effect may be more severe in shallow lakes, which can be more vulnerable to external changes. In the shallow polymictic Lake Balaton, a record-setting algal bloom developed in 2019 after 25 years of successful eutrophication management. It was partly caused by unusually long periods of intermittent stratification. Because climate change-induced stratification-related studies typically focus on deep lakes, we analyze 40 years of simulated water temperature time series of a large polymictic lake in this study. We quantify the changes in stratification and thermal structure. To reproduce the past four decades, we used the 1D General Ocean Turbulence Model (GOTM), which was driven by bias-corrected ECMWF ERA5 reanalysis time series. The calibration and validation of the model were made against high-frequency hydrometeorological observations from the open water. Measurements have been available from 2019 to the present, from spring to autumn. The role of water level and light conditions are examined in detail. Finally, we show the applicability of simple neural networks in calculating a shallow lake's thermal structure with strong daily cycles. The training and validation of the neural network model were made against the same data as for the 1D model. It is also evaluated against the GOTM, which is considered as the reference.

**Kristen Towne**, Eric Huber, Janine Lajavic and Gregory Wright, U.S. Fish & Wildlife Service, Alpena, MI, USA. **Evaluation metrics for an aquatic invasive species early detection program.**

It is well known that invasive species represent one of the largest risks to the native fauna of the Great Lakes. The most effective form of invasive species control is simple, prevent their introduction. However, people will inevitably fail in this; flooding will allow fish to escape from stocked ponds, unwanted aquarium fish will be released by well-intentioned owners, and non-native fish will be released unnoticed with a larger bucket of native bait fish. Assuming eventual introduction is unavoidable, the primary method to prevent a novel species from causing harm is to detect that species while it is still rare and geographically restricted. This need to detect novel species soon after their introduction gave rise to the US Fish and Wildlife Service Early Detection and Monitoring (EDM) Program. Since 2013, crews from four USFWS field offices have annually sampled for non-native fish throughout the Great Lakes. For many of those years, the program has wrestled with a simple question: How do we evaluate our ability to catch something that might not even be there? This presentation will demonstrate three techniques utilized by the Alpena, MI field office EDM program: the Chao analysis, a rare species analysis, and a contemporary species

analysis. The advantages and disadvantages of each will be discussed, and the results from a portion of Lake Erie will be shown as an example. The evaluation of AIS early detection programs is a vital component of the continuous effort to protect our native Great Lakes fauna.

**Lara Treemore-Spears**[1], Yongli Wager[1], Donna R Kashian[1], Carol J Miller[1], Rahul Mitra[1], Mark Cheng[2], Michelle Beloskur[3], Chris Bobryk[4], Jonathan Weyhrauch[5] and Weisong Shi[6], [1]Wayne State University, Detroit, MI, USA, [2]University of Alabama, Tuscaloosa, AL, USA, [3]Ingham Conservation District, Mason, MI, USA, [4]Clinton River Watershed Council, Rochester Hills, MI, USA, [5]Reroot Pontiac, Pontiac, MI, USA, [6]University of Delaware, Newark, DE, USA. **Advancing public knowledge of hidden threats – microplastics outreach across the Great Lakes region.**

In 2018, a team of academics and community groups came together with a lofty goal: reduce microplastics in the Great Lakes. With few proven technologies for detecting or measuring microplastics, let alone controlling them, and a lack of public awareness about microplastics and their health and environmental effects, the "SMART Management of Microplastics Pollution in the Great Lakes" team forged a public engagement and communication strategy. Starting with an advisory board extending across 7 states and Canada with diverse representation from local, regional, state and federal government, community organizations, utilities, industry and academia, the team developed pilot community engagement projects and communication feedback loops that helped refine programming and scientific investigations. Through the teamwork of this network of scientists and practitioners, the methods, materials and tools were developed to advance public and scientific understanding of and engagement in microplastics measurement, mitigation and control. Funded by the Great Lakes Protection Fund, with partners from Wayne State University, University of Alabama, Ingham Conservation District, Clinton River Watershed Council, Reroot Pontiac and others, the products of this work advance interdisciplinary approaches to reducing microplastics pollution.

**Kim Tremblay**[1], Nikki Commanda[2] and George Morgan[3], [1]Ontario Ministry of Natural Resources and Forestry, North Bay, ON, Canada, [2]Nipissing First Nation, Natural Resources Department, Nipissing First Nation, ON, Canada, [3]Ontario Ministry of Natural Resources and Forestry, Peterborough, ON, Canada. **Lake Nipissing Cisco – Adaptive and Resilient.**

Winter anglers on Lake Nipissing occasionally target Cisco (*Coregonus artedi*) and harvest has declined over the last forty years from over 10,000 per year in the 1980s to less than 1,000 in 2022. Cisco are also a by-catch component of the Nipissing First Nation commercial Walleye (*Sander vitreus*) gill net fishery, accounting for almost one-quarter of the fish caught from 2009 to 2022. Currently the by-catch accounts for over 95% of the annual Cisco harvest. Although Cisco abundance in the fall index netting projects varied from the 1998 to 2022 there was no significant trend. There was no difference in growth patterns between males and females (male Lmax = 408mm and female Lmax = 406mm). Females Cisco matured one year later than males (female age-at-50% =1.8 years and male age-at-50% maturity = 0.9 years) and at a slightly larger size (female size-at-50% maturity = 248mm and male size-at-50% maturity = 238mm). Cisco condition declined after the establishment of Spiny Water Flea (*Bythotrephes longimanus*). The adult mortality rate (Z) has been ~0.30 (~25% per year) throughout the time series. Although harvest dynamics and ecosystem changes have occurred Lake Nipissing continues to support a healthy Cisco population.

**Cary D. Troy**[1] and Hazem Usama Abdelhady[2], [1]Purdue University-West Lafayette, West Lafayette, IN, USA, [2]Lyles School of Civil Engineering, Purdue University, West Lafayette, IN, USA. **The Great Lakes Shoreline Model (GLSM): Development and Applications.**

Recent water level fluctuations in the Great Lakes have caused widespread shoreline changes. While water level projections for the Great Lakes are highly uncertain due to the offsetting effects of increased region precipitation and lake evaporation, the recent extremes and rapid shifts are thought to be indicative

of what future climate conditions may cause for Great Lakes water levels. To better predict, model, and manage the shoreline response to changing climatic conditions (both water levels and waves), we developed the Great Lakes Shoreline Model. The model is a reduced-complexity model that simulates the shoreline position as it evolves in response to wave and water level forcing. Importantly, this model modulates wave forcing based on the water level disequilibrium associated with rising and falling water levels. The model is applied to several Lake Michigan beaches, using shoreline positions derived from high temporal resolution satellite imagery as validation and calibration data. The model shows great promise in its ability to simulate the effect of changing water levels on wave-induced shoreline change, in contrast to ocean shoreline models that do not account for the water level effects in simulating shoreline position. Ongoing and future work seeks to generalize the model and its parameters beyond sites for which calibration data is available, which will ultimately serve to make the model transferrable to other locations.

**Justin Trumpickas** and Erin S. Dunlop, Ontario MNRF, Trent University, Peterborough, ON, Canada. **Seasonal spatial distribution and movement patterns of lake trout in Lake Simcoe.**

Lake trout (*Salvelinus namaycush*) are a species of management concern in Lake Simcoe, with declining abundance and limited natural reproduction. Among the pressures thought to impact this population are low hypolimnetic dissolved oxygen levels during the stratified season. To better characterize the habitat that lake trout are using, an acoustic telemetry array was deployed in Lake Simcoe starting in November 2020 (30 receivers) and growing to 42 receivers by June 2021 deployed in an approximately 4 km grid covering waters greater than 10 m depth. Lake trout were acoustically tagged in fall of 2020 (n=21) and 2021 (n=33). Detection data up to June 2022 were analyzed to estimate home range size and movement rates. These dependent variables were compared across seasons and between male and female fish to understand the factors affecting lake trout spatial distribution. A better characterization of lake trout seasonal habitat improves understanding of time periods when lake trout may be particularly impacted or restricted by habitat quality.

**Miles W Tryon-Petith** and Chin H Wu, University of Wisconsin-Madison, Madison, WI, USA. **Abrupt bluff recession near coastal structures under fluctuating water levels in Lake Michigan.**

Bluff recession is increasingly important with continued development of coastal communities. Bluff recession in the great lakes affects millions of lives, billions of dollars in the "maritime" economy, and thousands of miles of coastal habitat. Previous studies show that erosion is driven by natural and anthropogenic processes including water levels, waves, and coastal structure development. This presentation will reveal bluff recession in Southeastern Wisconsin under lowest to highest Lake Michigan water levels. Oblique and aerial imagery are used with LiDAR data and field measurements in Geographic Information Systems (GIS) to analyze bluff variation. Bluff recession is quantified using digitized bluff features and the Digital Shoreline Analysis System (DSAS). Field measurements are used to characterize the hydrodynamic environment. Results show that more intense regional bluff recession – over 1 m/yr – occurs under higher water levels and more intense storm events. Local recession is abrupt – up to 4 m/yr – at the margins of parallel coastal structures compared to undeveloped ("natural") areas. Nearshore downcutting near parallel structures may explain abrupt recession. In contrast, abrupt bluff recession near a pocket beach is less pronounced. Water level fluctuations are found to be a primary mechanism for abrupt bluff recession adjacent to coastal structures. Understanding relationships of bluff recession between coastal structures and natural environments can be a key to develop sustainable and resilient coastal protection strategies.

**Caroline M Tucker**[1], Dak de Kerckhove[2], Henrique Giacomini[2], Lifei Wang[3] and Nicholas E. Mandrak[4], [1]Ontario Ministry of Natural Resources and Forestry, Toronto, ON, Canada, [2]Ontario Ministry of Natural Resources and Forestry, Peterborough, ON, Canada, [3]University of Toronto Scarborough, Toronto, ON,

Canada, [4]Department of Physical and Environmental Sciences, University of Toronto Scarborough, Toronto, ON, Canada. **Estimating fish production in Lake Ontario wetlands.**

Despite the acknowledged importance of coastal wetlands as spawning and rearing habitat for freshwater fishes, quantitative estimates of fish production (i.e. the generation of fish tissue over time) are extremely rare, if not completely missing, for North American wetlands beyond habitat-suitability based indices. In a multi-agency partnership, we have developed a first estimate of fish production for 18 wetlands in Lake Ontario following a traditional instantaneous growth model applied to a standardized field protocol. A stage-structured, annual production model was developed and a Bayesian framework was used to estimate the specific abundances, instantaneous growth rates, and mortality rates for selected species. This model was first developed for the eight most abundant fish species (Black Crappie, Bluegill, Bowfin, Brown Bullhead, Largemouth Bass, Northern Pike, Pumpkinseed, and Yellow Perch) in a Bay of Quinte wetland that was intensively and seasonally sampled with electrofishing and larval tows from 2018-2020. This model was then applied to 17 neighbouring wetland sites using single-season boat electrofishing data to explore regional patterns of production. Production across the wetlands ranged from 340 to 1135 kg/ha/year, and appeared to be driven most by the presence of large-bodied species such as Bowfin or Common Carp. We discuss the relevance of this model for understanding how coastal wetlands contribute to the fisheries and off-shore stocks of the Great Lakes, as well as offer a new important metric to prioritize conservation efforts.

**Janvière Tuyisenge**, Anne van Dam, Gretchen Gettel and Ken Irvine, IHE Delft Institute for Water Education, Delft, Netherlands. **Assessing local environmental effects of cage fish farming on Lakes Kivu and Muhazi, Rwanda.**

Capture fisheries have been overexploited, leading to the development of cage aquaculture as an alternative for fish production. Such developments are rapidly spreading across Rwandan lakes: Kivu and Muhazi, colonizing understudied shallow and isolated zones. Uneaten fish feed, fish feces, and excretion products have adverse impacts on water and sediment quality and benthic processes, and the accumulation of sediment organic matter may lead to increased production of greenhouse gases. So far, possible environmental effects of the cage farms on Lakes Kivu and Muhazi have not been studied much. To formulate evidence-based regulations for sustainable cage fish farming in these lakes, it is essential to comprehend the environmental conditions at cage farms. This study compared nutrient concentrations and greenhouse gas fluxes between sites with and without cage aquaculture. According to the first results of the study show that average $NH_4$ concentration was 5.1 µg/L at sites without cages and 56.4 µg/L at sites with cages in Lake Muhazi. In lake Kivu, the concentration of $NH_4$ was also higher at cage sites (13.1 µg/L) than in cage-free sites (9.2 µg/L). Furthermore, results from Lake Kivu, show that methane gas concentration and fluxes were elevated inside cage farms. The $pCH_4$ varied from 82 to 526 µatm, and 80 to 200 µatm inside and outside cage farms, respectively. $FCH_4$ ranged between 0.6 and 191.9 mg/m$^2$/h in cage farms and 0.5 to 20 mg/m$^2$/h in sites without cages.

# U

**Diane Umutoni**, Akagera Management Company, Kayonza, East Province, Rwanda. **Effect of Octylphenol (OP) water exposure to sexually mature female mosquitofish, *Gambusia affinis* life history.**

The energy allocation to growth and reproduction, in relation to OP water exposure with different concentrations, was investigated in laboratory experiments with the sexually mature female mosquitofish, *Gambusia affinis*. My study investigated the energy allocation between reproduction and somatic growth in sexually mature female mosquitofish exposed to octylphenol (OP) in water for 28 days with 0 (control), 50 and 100 µg/l concentrations. Exposed females devoted less energy in reproduction and increased body energy storage. Additionally, a high number of well-developed fish with undeveloped or regressed ovaries

revealed, and the Chi-square test shown a significant association between this condition and OP concentrations. But still, the mechanism of OP reducing the ovarian development in sexually mature exposed fish is unclear. In conclusion, this study showed that OP increased the energy in body building which may result in obese individuals and the reduction in energy devoted to reproduction, and the elevated number of undeveloped ovary may affect the population with low number of offspring. This study results enforce the point that any stage of life cycle can be affected significantly by EDCs. In a continuous exposure, these results may rise a prediction of the species extinction and the protection of unexposed aquatic environment is needed as well as reducing the use of EDCs and reduce the release of wastewater into aquatic environment. **Keywords:** Energy allocation, OP concentrations, female mosquitofish, *Gambusia affinis*.

**Yoji Uno**, University of Toronto, Scarborough, Toronto, ON, Canada. **Development of wetland carbon cycle models: Applications for the Great Lakes Basin.**

It is widely recognized that wetland plays various important roles in chemical dynamics. Particularly, the function of wetlands as a carbon sink is one of the most important characteristics for the climate change studies in Canada, since it occasionally sequesters large amounts of carbon as a form of peat. While the potential of wetlands as nature-based climate solutions is generally agreed, technical difficulties still exist for its successful applications. One of the problems is the difficulties to develop robust wetland models, which reasonably estimate the impact of the restoration on carbon cycle in geographically and temporally diversified wetlands. Indeed, past studies show that the most of the researches has been conducted in a site-specific manner, and its generality, or applicability of the methods in the different environmental conditions, does not seem to be clear, particularly in terms of inundation status, nutrient conditions, and soil and vegetation types, etc. In this presentation, the potential solutions to solve these problems will be discussed, mainly being focused on our current research work, in which integration of multiple models and development of model ensembles were explored, considering the unique conditions in the Great Lakes Basin.

**Noel R Urban**[1], Judith Perlinger[1], Enid M Partika[1], Azmat Naseem[1], Libia Hazra[1] and Bill Mattes[2], [1]Michigan Technological University, Houghton, MI, USA, [2]Great Lakes Indian Fish and Wildlife Commission, Odanah, WI, USA. **Do fish contaminant concentrations reflect spatial scales of ecosystem structure in Lake Superior?.**

It has been argued that the plasticity in diet of the top predators in Great Lakes food webs (lake trout, *Salvelinus namaycush*) lends them adaptive capacity to avoid localized stressors impacting lower trophic levels. However, spatial patterns in fish contaminant concentrations suggest that lake trout reflect relatively localized stressors. In this study, we examine empirically whether systematic spatial differences in contaminant concentrations in lake trout in Lake Superior are indicative of spatial variations in ecosystem structure and function. Specifically, we examine whether different contaminant concentrations in fish tissue are indicative of distinct fish populations with differing food web structures or differing resource availability. A combination of stable isotope ratios, gut content analyses, lipid content and fatty acid composition, contaminant profiles, and age-length relationships are used to determine food web structures and fish growth rates. This presentation will contrast two closely adjacent regions of the lake with large differences in fish contaminant concentrations to evaluate the roles of food web structure and resource availability.

# V

**Reza Valipour**[1], David C Depew[2], Phil Fong[1], Rajesh R Shrestha[3], Jun Zhao[1] and Yerubandi R. Rao[1], [1]Environment and Climate Change Canada, Burlington, ON, Canada, [2]Environment and Climate Change

Canada, Water Science and Technology Branch, Canada Centre for Inland Waters, Burlington, ON, Canada, [3]Environment and Climate Change Canada, Victoria, BC, Canada. **Year-round ecological responses of two large lakes using process-based hydrodynamic and water quality models.**

Ecological responses of Lake Erie and the Lake of the Woods are studied in year-round multi-year simulations including ICE periods. The process-based hydrodynamic and water quality model of these lakes were initialized, calibrated, and validated using observations from mooring deployments, lake-wide water quality monitoring program, satellite images, and different functional groups of total chlorophyll-a. The models were forced by observed and projected meteorological data, riverine inflows, and outflows. For the Lake of the Woods case study, we further examined model runs using future climate projections for 2079-2100 (CanESM2 and CRCM5-NEMO climate models under RCP 8.5 emissions). The modeled ecological responses suggest noticeable shifts in favorable periods of predominant algae functional groups due to temporal changes in simulated optimum water temperatures, significant changes in ice duration, and ice thickness by the end of the century.

Aidin Jabbari[1], **Reza Valipour**[2], Josef D. Ackerman[3] and Yerubandi R. Rao[2], [1]Fisheries and Oceans Canada, Bedford Institute of Oceanography, Dartmouth, Halifax, NS, Canada, [2]Environment and Climate Change Canada, Burlington, ON, Canada, [3]Department of Integrative Biology, University of Guelph, Guelph, ON, Canada. **Nearshore-offshore exchanges by enhanced turbulent mixing along the north shore of Lake Ontario.**

Seasonal nearshore-offshore exchanges by coastal upwelling events in large lakes can play a significant role in nearshore nutrient dynamics, affecting lake productivity and water quality. We analyzed field observations along the north shore of Lake Ontario, collected in the summer of 2018, focusing on the littoral zone and specifically the *Cladophora* habitat zone (<15 m), to investigate episodic enhanced vertical mixing by coastal up/downwelling events. Vertical turbulent diffusivity ($K_z$) based on the buoyancy Reynolds number above the thermocline during downwelling events was generally higher than those below the thermocline during upwelling events (i.e., ~$10^{-5}$ $m^2$ $s^{-1}$ vs. ~$10^{-6}$ $m^2$ $s^{-1}$, respectively); while $K_z$ at the thermocline depth increased by ~ two orders of magnitude during upwelling events. Our results suggest that $K_z$ based on the Richardson number parameterization, which only accounts for large-scale current shear and stability and incorporates an adjustable parameter, $K_0$, is ~ ten times higher than the $K_z$ based on the buoyancy Reynolds number. Analysis of historical wind records indicates that the frequency of coastal upwelling favorable winds on the north shore of Lake Ontario has increased by >45% over the last thirty years - suggesting an increasing trend of nearshore-offshore nutrient exchanges as a contributing factor for the nearshore water quality management.

Serghei A. Bocaniov[1], Donald Scavia[2] and **Philippe Van Cappellen**[3], [1]Department of Earth and Environmental Sciences, Ecohydrology Group, University of Waterloo, Waterloo, ON, Canada, [2]University of Michigan, Ann Arbor, MI, USA, [3]Ecohydrology Research Group, University of Waterloo, Waterloo, ON, Canada. **The phosphorus mass-balance of Lake Erie reveals an important contribution of in-lake loading.**

Several in-lake mechanisms can add significant amounts of new and recycled phosphorus (P) to the water column, altering a lake's response to external nutrient loading and increasing eutrophication symptoms. Management of eutrophication in lakes typically focuses on reducing external P loads. However, to generate realistic predictions on which to base management decisions, information on internal P loading is required. Internal P inputs are difficult to directly measure and to scale up in time and space, especially in large lakes. Mass balance modeling provides a conceptually simple theoretical tool to estimate the magnitude of internal P loads when integrating over a sufficiently long time span to allow inputs and outputs to come into balance (steady state condition). We generated a steady-state model representing the post-2000 net annual total P (TP) budget for the Lake St. Clair–Lake Erie system. The budget shows that the net TP output from the system substantially exceeds the sum of the external TP inputs. To balance the budget, in-

lake processes must add 3783 metric tons of P per year to the water column, or about one third of all externally derived TP inputs combined. We further assess the distribution of internal P loading fluxes across the lake system's basins, as well as the responsible processes.

**Joris Van Zeghbroek**[1], Rochelle Sturtevant[2], El Lower[3], Ashley K Elgin[4] and Felix Martinez[5], [1]Michigan Sea Grant, Ann Arbor, MI, USA, [2]NOAA/GLERL - GLANSIS, Michigan Sea Grant, Ann Arbor, MI, USA, [3]GLANSIS, Michigan Sea Grant, Ann Arbor, MI, USA, [4]NOAA GLERL, Muskegon, MI, USA, [5]NOAA - Great Lakes Environmental Research Laboratory, Ann Arbor, MI, USA. ***GLANSIS* Education Hub: Ensuring that AIS education is relevant, inspiring, and accessible.**

Aquatic invasive species education is a key component of Great Lakes conservation and incorporates a wide range of topics covering a vast fresh water system. The Great Lakes Aquatic Nonindigenous Species Information System's (GLANSIS) goal is to serve as a one-stop shop for information about aquatic nonindigenous species in the Laurentian Great Lakes region of North America. To help achieve this goal GLANSIS is launching an initiative to create an Educator Hub that will provide a curated set of educational resources related to native and non-native species of the Great Lakes. Our goal is to utilize scientific datasets and best rhetoric practices to create engaging materials that are accessible to a diverse range of communities, especially those historically underrepresented in the sciences. As part of this effort we will be creating and updating instructional guides with a focus on increasing the usability of our resources for teachers. The process of curating and creating educational resources will be outlined, including the successes and challenges encountered along the way. This project is the beginning of a multiyear effort to ensure that youth understand the impacts and importance of native and non-native species in the Great Lakes and are inspired to take action in their own communities.

**Andrea Vander Woude**[1] and Songzhi Liu[2], [1]NOAA GLERL, Ann Arbor, MI, USA, [2]Cooperative Institute for Great Lakes Research, University of Michigan, Ann Arbor, MI, USA. **Climate change effects derived from long-term satellite data records on NOAA's Great Lakes CoastWatch Node.**

Satellite data records typically span multiple decades and provide a snapshot of recent climate change effects, especially related to rapidly changing large lake systems. The Great Lakes are an ideal large lakes testbed to approximate multi-decadal scale climate variability from satellite climate data sets that are derived from NOAA's Great Lakes CoastWatch Node, as the data portal for NOAA's climate (e.g. weather patterns and surface temperatures) and water quality parameters. Advancement of satellite data retrievals within CoastWatch's Great Lakes Node includes new validation efforts to better approximate satellite parameter retrievals, that feed into decadal climate change variability calculations on long-term satellite time series, and updated algorithms for lake-wide assessments of water quality. The Great Lakes CoastWatch node's upcoming novel products include model parameters accessible in tandem with satellite data retrievals and almost a decade of hyperspectral airborne data over the span of the Great Lakes, supporting multi-agency science priorities for future space-borne satellite missions under federal agencies such as NOAA and NASA.

**Angelica Vazquez Ortega** and Olusola Oyewumi, Bowling Green State University, Bowling Green, OH, USA. **Assessment of Lake-Dredged Sediments as Farm Soil Amendment growing Specialty Crops.**

More than 800,000 cubic yards of lake sediments (LS) are dredged annually from the Western Lake Erie Basin (WLEB) to ensure navigable waterways. The LS were typically disposed in the open-lake waters. However, there is a concern that open lake dredged disposal can redistribute nutrients in the water column exacerbating eutrophication and contributing to harmful algal blooms. The state of Ohio passed an ordinance on July 2020 prohibiting the open lake dredged disposal in the WLEB. This research explores agricultural uses for LS growing specialty crops. Soil blends including 100% farm soil, 90% farm soil and 10% LS, and 100% LS are being tested to understand soil health and food safety. The research objectives

include (1) determination of bioaccumulation of heavy metals and polyaromatic hydrocarbons (PAHs) in the edible fruits and plant tissue to ensure food safety, and (2) plant nutrient dynamics on the above and below biomass by measuring the carbon, nitrogen, and phosphorus ratios, and crop yield. We employed greenhouse and field experiment approaches to characterize the soil blends and biomass. Previous research indicated no preferential bioaccumulation of heavy metals and PAHs in soybeans.

**Tim Vehling**, Adam Cornwell, Kamil Zaniewski and Robert Stewart, Lakehead University, Thunder Bay, ON, Canada. **Identifying significant groundwater recharge areas and hydrological function assessment of the Neebing River.**

This study provides a hydrological function assessment of the Neebing River, which becomes an urban stream through the City of Thunder Bay and has historically been prone to flooding. Hydrological function assessments have been conducted in other parts of Ontario; however, there is limited information on northern watersheds. These previous assessments provide a useful example of the ongoing work with the Neebing River. This project consists of three components: thematic mapping, surface water and groundwater interactions modelling and isotope sampling. Mapping the significant groundwater recharge areas (SGRA) identifies areas with an above-average contribution to the groundwater within the watershed. Infiltration rates are modelled from topographic, soil and land use data. Statistical analysis of climatological and hydrological variables is used to identify any correlations and surface-subsurface water interactions on a seasonal and annual scale. Stable isotope sampling is used to validate the statistical analysis and the derivation of baseflow from streamflow to ensure accurate conclusions. Expected results include a relationship between the distribution of SGRAs and groundwater contribution to streamflow and a temporal relationship between climatic and hydrologic variables. Gaining a better understanding of the Neebing River watershed and establishing baselines for the hydrologic function of groundwater and surface water interactions will help with future studies of the impacts of climate change on this watershed.

**Edward Verhamme**[1], Kenneth Gibbons[1] and Ge Pu[2], [1]LimnoTech, Ann Arbor, MI, USA, [2]Cleveland Water Alliance, Ann Arbor, OH, USA. **High Density Sensor Networks for the Great Lakes - Beyond Erie.**

Since 2020, LimnoTech and the Cleveland Water Alliance have been working to substantially advance the deployment of new sensing technology on Lake Erie. Because of these efforts Lake Erie is now the most "wired" of the Great Lakes. The higher density shoreline stations along the Ohio shoreline are able to monitor the movement of algal blooms, hypoxia, track fish movements, wave, wind and water level observations. A new low power wide area network (LPWAN) was also deployed over 1200 sq miles to cover large portions of the lake with low bandwidth spread spectrum technology that will accommodate tens of thousands of potential sensors and shoreline use cases. This presentation will cover some of the new large scale phenomenon that are now being monitored as well as talk about how the network is growing to accommodate other sensors and users. Other portions of the Great Lakes could benefit from a similar approach which considers equipment costs, long term maintenance, cross organization funding, workforece development and training, as well as meeting multiple regional science/monitoring objectives.

**Clara Voorhees**, D'Youville University, Buffalo, NY, USA. **University Undergraduate General Education Curriculum and The Great Lakes.**

At D'Youville University in Buffalo, NY we have created a General Education Course: BIO 286 The Great Lakes: Natural History, Ecology and Conservation for our General Education Core Curriculum. This course incorporates Native American Indian, ecological, and biological history of the Great Lakes Region and the impact that humans have had, and will have, as region continues to change. With a 7:1 student-to-faculty ratio (53% of classes have fewer than 20 students), all D'Youville students receive the benefit of a close-knit, supportive learning environment and student-centered faculty. Striving to be

reflective of the Buffalo community, DYU actively recruits first-generation and economically disadvantaged students—25% of all undergraduates are Pell grant-eligible, 60% are first generation, 18% are underrepresented minorities (URM), and 74% are women. More than 81% of undergraduates come from New York State, and 73% are from the Buffalo-Niagara region. To remove barriers to success within the classroom, DYU faculty utilize established and innovative pedagogies, such as flipped classroom with active learning activities, and gamification of learning. In BIO 286 undergraduate students from all majors at the university can learn about the great lakes, most specifically Lake Erie. Students learn about the Great Lakes through case studies, management and planning activities, habitat analyses, and an epic finale in which the students design, create and play a boardgame "Great Lakes Clue".

Tassiane Pereira Junqueira, Nathan Beckner-Stetson and **Bas Vriens**, Queen's University, Kingston, ON, Canada. **Exploring Rare Earth Elements Distribution Patterns in the Great Lakes.**

Rare Earth Elements (REEs) are increasingly used for (high-tech) industrial applications and green technology, but their baseline concentrations and long-term distribution patterns in the Great Lakes remain poorly understood. We studied dissolved REE concentrations in >80 surface water samples collected from Lakes Huron, Erie and Ontario in 2021 and 2022 to assess their average concentration ranges. Following Oddo-Harkins rule, average REE concentration ranges abundances varied significantly (>3 orders-of-magnitude) between elements. In both years, concentrations were heterogeneous spatially across the lakes, but while Lake Huron had the highest dissolved REE levels, no accumulation of REE levels upstream-to-downstream through the lakes was observed. Light REEs were enriched over heavy REEs particularly in samples closer to shore, implying that riverine input is a major pathway by which these REEs are loaded to the lakes. Finally, we used normalization and pattern-filling to assess non-geogenic contributions and observed anomalies for Gd, Eu and Ce, particularly in Lake Ontario. As we are further examining REE sourcing, redox fractionation, and the role of select biogeochemical processes (sedimentation), this work provides important baseline information on REE dynamics in the Great Lakes.

**Dillon Vyn**[1], Clare E. Robinson[2], Pradeep Goel[3], Imtiaz Shah[4] and Sabrina Jivani[1], [1]Western University, London, ON, Canada, [2]Civil and Environmental Engineering, Department of Civil and Environmental Engineering, Western University, London, ON, Canada, [3]Ontario Ministry of the Environment, Conservation and Parks, Etobicoke, ON, Canada, [4]Upper Thames River Conservation Authority, London, ON, Canada. **Effect of Land Use Type and SCMs on Nonpoint Source Phosphorus in a Cold Climate Urban Subwatershed.**

The relative contribution of phosphorus (P) from different urban land use types and its seasonal variations is not well understood, especially for cold climates. Further, the effectiveness of stormwater control measures (SCMs) in reducing P loads are poorly quantified at the subwatershed scale. To address these gaps, detailed monitoring of concentrations and loads of total suspended solids (TSS), total P (TP), soluble reactive P (SRP), and nitrate (as $NO_3$-N) was conducted over a 15-month period in an urban subwatershed in London, ON. Monitoring locations were set up at outlets of different urban land use types and across different SCMs. Grab samples were collected during rain, snowmelt, and baseflow conditions, and autosamplers were deployed at downstream sites during precipitation events. The highest SRP concentrations were observed during large late winter snowmelt events and large fall rain events. TP and TSS concentrations were highly variable during events with TP often considerably larger than SRP. SRP concentrations were consistently highest at the outlet of an older low-density residential area compared to other land uses, with construction also contributing to high outlier SRP concentrations. Finally, while the traditional wet pond significantly decreased SRP concentrations, the monitored swales and bioretention systems had no significant influence on SRP concentrations. Study findings will assist in predictions of P loads from cold climate urban areas and aid decisions for reducing nonpoint source urban P loads.

# W

**Alexander Scott Waldie**, University of Waterloo, Waterloo, ON, Canada. **Oxidative Enzyme-Catalyzed Surface Functionalization of Polyethylene.**

Polyethylene represents more than a quarter of all plastics and is employed in a variety of single-use products, such as plastic bags. Once discarded, these products slowly degrade in the environment, eventually forming small plastic particles called microplastics. These microplastics pollute the Great Lakes and can last up to centuries due to the refractory nature of polyethylene. Recent advances indicate that oxidative enzymes may play a role in catalyzing the eventual degradation of polyethylene by inserting oxygen groups into the plastic. Therefore, an examination of a variety of oxidative enzymes, aided by molecular modeling, will provide insight into the possible mechanisms for degrading polyethylene. This will be achieved by utilizing commercially available oxidative enzymes, under optimized conditions, to oxidize polyethylene which will be compared to chemically oxidized polyethylene. The oxidized plastics will be analyzed using a variety of instruments and molecular modeling will be used to aid in the determination of possible enzymatic mechanisms. Understanding the role enzymes play in degrading polyethylene could provide insight into the initial steps of its biodegradation and methods to accelerate its decomposition.

Mathew Acre[1], James J Roberts[2], Ryan Trimbath[3], Curtis Wagner[4], Ramsey Langford[5], Marc Mills[6] and **David Walters**[7], [1]U.S. Geological Survey, Columbia Environmental Research Center, Columbia, MO, USA, [2]U.S. Geological Survey, Great Lakes Science Center,, Sandusky, OH, USA, [3]U.S. National Parks Service, Cuyahoga Valley National Park, Brecksville, OH, USA, [4]Ohio Department of Natural Resources, Division of Wildlife, Akron, OH, USA, [5]Summit Metro Parks, Akron, OH, USA, [6]USEPA, Office of Research and Development, National Risk Management Research Laboratory, Cincinnati, OH, USA, [7]USGS, Columbia Environmental Research Center, Columbia, MO, USA. **Pulling the plug: Space use and movement of fishes prior to removal of a large dam.**

Dams are significant barriers to fish passage. Nearly 1200 dams were removed in the U.S. over the last two decades with more slated for removal. Ohio Edison Dam on the Cuyahoga River was built in 1913 (OH) and will be removed in 2025. We tagged 117 fish between May and October, 2022 with acoustic telemetry tags to assess fish behavior pre-dam removal. Tagging occurred in three river zones: downstream of the reservoir (DS), in the reservoir (RE), and upstream of the reservoir (US). Fish tagged included Northern Pike *Esox lucius*, Smallmouth Bass *Micropterus dolomieu*, Northern Hogsucker *Hypentelium nigricans*, and White Sucker *Catostomus commersonii*. We deployed acoustic receivers spaced at ~1 km along 22 river km. We collected 1.1 million unique detections; 99% were for fish that never left the detection field of the same receiver (no movement). The remaining 1% of detections represent small movements (n = 11,006; i.e., moving in and out of the same receiver's detection field) and state changes between two receivers (n = 1,999). Fish in US and DS segments were more likely to exhibit directional movements and greater dispersal than in RE segment. Fish in RE segment exhibited greater cumulative distance moved but nearly zero net dispersal. They moved more often and faster than those in US and DS segments, likely owing to limited habitat in the isolated RE system. This behavior has been recorded in other systems and is indicative of poor-quality habitat (i.e., fish move farther and more frequently to access necessary resources). No movements between the three segments have been detected.

**Elizabeth Wanderi**[1,2,3] and Frank Onderi Masese[3], [1]Kisii University, Kisii 40200, Kenya, [2]Kenya Fisheries Service, Lodwar, Kenya, [3]University of Eldoret, Eldoret, Kenya. **Challenges facing the fisheries and economic viability of desert lakes- a case of Lake Turkana, Kenya.**

Lake Turkana is the largest permanent desert lake in the world and the largest lake in Kenya, rich in endemic fish species. It is a vital source of food, water for drinking and watering livestock, papyrus, and transport, and home to the indigenous community, the El Molos. Despite hosting approximately 48 fish

species, food security, hunger, and malnutrition are still significant challenges facing the community depending on these resources. The lack of opportunities to market fish catches from Lake Turkana is attributed to value chain bottlenecks and socio-economic factors attributed to the remoteness of the lake, climate change, lack of electricity, poor roads, post-harvest losses, cultural barriers, and illiteracy among the fisherfolk. The post-harvest losses have resulted in losses of catches as most fish fail to meet hygienic standards. Consequently, most fishermen rely on traditional sun-drying methods to preserve fish which is not sustainable. Also, sun-drying fish on beaches reduce the quality of the fish due to the accumulation of sand particles. This paper presents value chain bottlenecks that hinder the marketability of Lake Turkana fish which has consequently consigned the fisher community to unrelenting poverty. We also discuss existing opportunities for eliminating the bottlenecks to make the fisheries more sustainable and the fisher communities more economically empowered. The study findings are based on anecdotal evidence, personal experiences, conversations with the fisherfolk, value chain actors, and a literature review.

**Gloria Wang** and Donald Jackson, University of Toronto, Toronto, ON, Canada. **Environmental variables associated with fish biodiversity in stormwater ponds in Ontario.**

Urbanization is associated with the ecological degradation of streams due to high inflows of stormwater runoff from impervious surfaces. Stormwater ponds (SWPs) are artificial ponds designed to divert runoff from streams by retaining stormwater before slowly releasing it into streams. In highly urbanized areas where aquatic habitat is otherwise scarce, SWPs can be biodiversity hotspots for many aquatic taxa. However, many SWPs can suffer from salinization, pollution, eutrophication, and hypoxia that affect aquatic species potentially using these ponds. While groups such as benthic invertebrates have been well studied, there is little existing research on fishes in SWPs despite reports of fish being found in them. We sampled fish species composition in 50 SWPs from Brampton, Ontario, along with the associated water quality characteristics, to determine how environmental conditions may impact the fish communities. We determine the relative importance of water quality, pond design, and landscape variables in predicting fish species richness and community composition. As SWPs release into the headwaters of adjacent streams, their contents are likely to impact adjoining streams, rivers, and ultimately Lake Ontario. The findings of this study can help inform SWP management to improve ecological function, as well as identify the potential effects of SWP outflow on downstream waters.

**Jia Wang**[1], Erika Maneke[2], James Kessler[1], Lacey Mason[1] and David Cannon[3], [1]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, USA, [2]Department of Agronomy, Purdue University, West Lafayette, IN, USA, [3]Cooperative Institute for Great Lakes Research, University of Michigan, Ann Arbor, MI, USA. **Interannual Variability of Ice Cover in Green Bay and Western Lake Erie in the Great Lakes.**

Ice cover on the Great Lakes affects the ecology, biology, and economy of the Great Lakes area, and it also serves as an indication of the regional climate. Ice cover data from the National Ice Center was used to analyze Green Bay and Western Lake Erie, two regions of interest for winter ecology and spring blooms, for the 1973-2021 time period. Green Bay and Western Lake Erie are comparable in bathymetry, but Green Bay is located at a more northern latitude. The effect of this can be seen as Green Bay has a higher average ice concentration than Western Lake Erie. The standard deviation calculated for Western Lake Erie's average daily ice cover concentration is larger than Green Bay's, indicating that Western Lake Erie's ice cover is more variable and therefore harder to predict. The annual average ice cover of both regions shows a large interannual variability over time, in response to the atmospheric teleconnection pattern forcings such as ENSO. The annual average ice cover and the annual maximum ice cover in Green Bay and Western Lake Erie have exhibited negative trends, meaning less ice cover occurs in the present compared to the past. The first and last ice cover dates in both regions have demonstrated a negative trend. The duration of ice cover, which plays a crucial role in ecological processes, has become shorter for Western Lake Erie increases at 0.8 days/decade for Green Bay, while decreases at ~4 days/decade for Western Lake Erie. Overall, annual

average ice cover (AAIC) has shown a long-term declining trend from 1973-2021 at 5.7%/decade in Western Lake Erie and 4% in Green Bay.

**Lifei Wang**[1], Nicholas E. Mandrak[2], Dak de Kerckhove[3], Caroline M Tucker[4], Henrique Giacomini[3] and Jeff Wright[5], [1]University of Toronto Scarborough, Toronto, ON, Canada, [2]Department of Physical and Environmental Sciences, University of Toronto Scarborough, Toronto, ON, Canada, [3]Ontario Ministry of Natural Resources and Forestry, Peterborough, ON, Canada, [4]Tucker Consulting, Toronto, ON, Canada, [5]Ontario Power Generation, Tiverton, ON, Canada. **Comparison of fish communities in Lake Ontario coastal wetlands.**

Great Lakes coastal wetlands are critical habitats for ecologically and economically important species. Such habitats are susceptible to climate change and anthropogenic disturbances, and monitoring of their fish communities is important for ecological sustainability. This study compared fish communities in coastal wetlands using data collected from Big Island Wetland (BIW) Habitat Bank and Durham Region Coastal Wetland Monitoring Project in Lake Ontario between 2015 and 2020. Principal component analysis and correspondence analysis were used to examine the relationships among 31 wetlands based on nine common species (Black Crappie, Bluegill, Bowfin, Brown Bullhead, Common Carp, Largemouth Bass, Northern Pike, Pumpkinseed, and Yellow Perch). Wetlands were grouped according to geographic locations (eastern group 76°W-77°W; western group 78°W-79°W) and environmental indicators: index of biotic integrity (IBI), number of native species (SNAT), percent piscivore biomass (PPIS), number of native individuals (NNAT), and percent non-indigenous biomass (PBNI). Fish composition and abundance in the wetlands were significantly associated with IBI, SNAT, NNAT and PBNI. Brown Bullhead, Common Carp and Northern Pike were more likely to occur in the western wetlands. Smaller-bodied fish species, such as Pumpkinseed, Yellow Perch, Bluegill, Largemouth Bass, and Black Crappie, occurred more frequently in the restored BIW. Results suggested restored wetlands, such as BIW, show potential in serving as valuable habitats for the Great Lakes fish communities.

**Lizhu Wang**[1], J. Val Klump[2], Gail Krantzberg[3], Matthew Child[1] and Allison Voglesong Zejnati[4], [1]GLRO, International Joint Commission, Windsor, ON, Canada, [2]University of Wisconsin-Milwaukee, Milwaukee, WI, USA, [3]McMaster University, Hamilton, ON, Canada, [4]International Joint Commission, Windsor, ON, Canada. **Great Lakes Science Strategy for the Next Decade.**

The Great Lakes are transforming rapidly in response to climate change, far-reaching land alterations, and legacy and emerging stressors, which requires cutting-edge science and surveillance to anticipate and prevent these threats to protect the wellbeing of the 40 million residents who rely on the lakes and the region's economy. However, support for scientific research of the lakes has not kept pace with the need for fundamental, process-oriented investigation and prediction. We too often lack basic information and understanding required to document and forecast change, mitigate impacts, and restore and preserve the ecosystem. To address this need and fulfill its responsibility identified in the Great Lakes Water Quality Agreement, the International Joint Commission Science Advisory Board developed a Great Lakes Science Strategy to define science and traditional knowledge needs for understanding changes to the lakes for the protection of the economic, social, and environmental health of the region. This Strategy was developed through a collaborative process engaging hundreds of scientists, managers, and practitioners. The Strategy includes six major recommendations that will require approximately USD $100 M in new annual investments to accomplish. The next step is to implement the Strategy by establishing a partnership coalition to formulate a detailed Science Plan that is trans-national in scope and identifies specific science needs and activities, their anticipated costs, and a description of sustainable management and governance arrangements.

**Qi Wang**[1] and Leon Boegman[2], [1]Queen's University, Kingston, ON, Canada, [2]Civil Engineering, Environmental Fluid Dynamics Laboratory, Department of Civil Engineering, Queen's University, Kingston, ON, Canada. **Computational Water Quality Modelling of Western Lake Erie.**

During the 1970s, harmful algal blooms (HABs) were common occurrences in western Lake Erie. Remediation strategies reduced TP loads and bloom frequency; however, HABs have reoccurred since the mid-1990s, likely forced by climate change. Given these concurrent changes in nutrient loading and climate forcing, there is a need to develop management tools to investigate historical changes in the lake and predict future water quality. Herein, we applied coupled one-dimensional (1D; AED-GLM) and three-dimensional (3D; AEM3D) hydrodynamic and biogeochemical models to reproduce water quality conditions of western Lake Erie from 1979-2015 and 2002-2014. The 1D model was calibrated/validated against observations of water temperature, TP, $PO_4$, $NH_4$, $NO_3$, chlorophyll-*a*, chlorophytes, cyanobacteria, diatoms, and cryptophytes. A sensitivity analysis shows that 40% P reduction is necessary to bring blooms under the mild threshold. The 3D model was calibrated/validated against observations of temperature, TP, $PO_4$, chlorophyll-*a*, and phytoplankton succession. The results indicate that this model can be calibrated using a single parameter set for decade simulations. Because 3D and 1D models require different computational power and have different agreement with observations, we cross-compared simulations from two models against observations from the Maumee River mouth to mid-basin. The results show that 1D AED-GLM performed better in capturing bloom years, while 3D AEM3D performed better in reproducing spatiotemporal nutrient and phytoplankton variations.

**Shuyang Wang**[1], Clare E. Robinson[1], James W. Roy[1,2] and Adam Yates[3], [1]Department of Civil and Environmental Engineering, Western University, London, ON, Canada, [2]Water Science and Technology Directorate, Environment and Climate Change Canada, Burlington, ON, Canada, [3]Department of Biology, University of Waterloo, Waterloo, ON, Canada. **Potential phosphorus release and retention from streambed sediments with changing stream pH.**

Eutrophication due to excessive phosphorus (P) loads is a major challenge for streams and lakes in the Laurentian Great Lakes Basin. This study conceptually explores the potential for stream pH changes to impact P retention-release from streambed sediment by (i) synthesizing prior experimental data quantifying the relationship between pH and sediment P exchange, and (ii) evaluating stream pH changes that occur over multiple time scales using current and historical data in Ontario, Canada. Synthesis of experimental data showed sediment P exchange is more sensitive to pH changes for pH >7. Analysis of historical data showed that 84% of 157 monitored streams across Ontario experienced long-term pH increases over the last 35 years, favouring streambed P release. Over this period median pH increase was 0.14 for streams in calcareous-dominant and 0.24 for streams in non-calcareous dominant regions. Over smaller temporal scales, large diel pH fluctuations up to 1.3 pH units occurred in some streams in summer, while precipitation and snowmelt events caused a pattern of rapid pH decline and subsequent recovery of pH (up to 1.7 pH). Such rapid changes could potentially drive short-term release and retention of P. Further, the long-term pH increase may enhance P release-retention that occurs in response to shorter-term pH fluctuations. The study findings suggest that pH changes may be important controls on streambed P release-retention, with implications for predictions of P loading from streambeds to streams and downstream water quality.

**Meghan Ward**[1] and Jeff Bowman[2], [1]Trent University, Peterborough, ON, Canada, [2]Ontario Ministry of Natural Resources and Forestry, Peterborough, ON, Canada. **Coastal wetland biodiversity declines when *Phragmites aus.* invades at Point Pelee National Park.**

In North America, the invasive common reed (*Phragmites australis*) has invaded coastal wetland habitat and now dominates over the native vegetation and disrupts invertebrates and anuran communities. Point Pelee National Park (PPNP) is located on the shores of Lake Erie in Ontario, Canada. Approximately 70% of Point Pelee National Park consists of marshland, making it one of the largest remaining Great Lakes

coastal wetlands in Canada. PPNP has been designated an Important Bird Area and a Wetland of International Significance by UNESCO. There are more species at risk found in this region than any other national park in all of Canada, with 71 species of COSEWIC designation (63 of which are protected under SARA). Many of the species at risk rely on the functioning wetlands for habitat, breeding, and subsistence. Unfortunately, the wetlands in PPNP have become dominated by invasive *Phragmites*. To reduce the amount of invasive-dominated areas and increase marsh biodiversity, a 5-year management plan was proposed by Parks Canada to remove five hectares of *Phragmites* growth. I am addressing the question: will the removal of 4 ha of invasive *Phragmites* from PPNP impact the native flora and fauna? This question will be addressed through the study of aquatic vegetation communities, invertebrate communities, and anuran densities. We found that the vegetation, invertebrate, and anuran communities differ when compared between *Phragmites*-invaded wetlands *Phragmites*-treated wetlands, and Remnant wetlands at PPNP.

**Jennifer Wardell**[1], Shadi Moradi[1], Mary Anne Evans[1] and Peter C Esselman[2], [1]United States Geological Survey, Ann Arbor, MI, USA, [2]U.S. Geological Survey, Great Lakes Science Center, Ann Arbor, MI, USA. **A comparison of underwater images and diver-based methods to assess percent cover of submerged aquatic vegetation.**

The status, drivers, and control of benthic algae have become important research topics in the Great Lakes region as managers seek strategies to control algal impacts on ecosystems. Cladophora is a major component of submerged aquatic vegetation (SAV) in the Great Lakes along with several other genera of benthic macroalgae. Traditional methods for benthic algae assessment include collection by SCUBA divers and are inherently limited in their spatial coverage. In contrast, underwater remotely operated and autonomous camera systems hold promise for the assessment of algae extent and drivers of growth. This research utilizes diver estimates of percent SAV coverage and estimates from photographs taken by an autonomous underwater vehicle (AUV). We explore the correlation between quadrat and mesoscale summaries of SAV abundance and the implications of these methods for adequate sampling.

**Colleen Wardlaw**[1], Meggie Dang[1], Karen Kidd[1] and Ryan Prosser[2], [1]McMaster University, Hamilton, ON, Canada, [2]University of Guelph, Guelph, ON, Canada. **Transfers of microplastics from aquatic to terrestrial food webs via emergent insects.**

Microplastics are a persistent and widespread contaminant found in aquatic environments. Aquatic insects spend larval life stages in aquatic ecosystems where they may interact with microplastics. Few studies consider the impacts of microplastics on emergent insect communities and their capacity to carry microplastics from aquatic to terrestrial environments as emerged adults. Further, little is known about how riparian predators are exposed to and impacted by microplastics. This study takes place over three time points up and downstream of four municipal wastewater treatments plants in the Grand River watershed, Ontario to assess wastewater treatment facilities as a source of microplastics to aquatic ecosystems. Here we quantify the amount of microplastics in base resources of sediment and periphyton, the amount of microplastic being ingested by larval mayflies, caddisflies and midges, and examine the retention of microplastics through metamorphosis with the adult form of these insects into riparian spiders. Microplastics are extracted from sediment with density separations, from periphyton using $H_2O_2$ digestions, and insects and spiders using a combination of $H_2O_2$ and chitinase. This research will address a key gap in our understanding by providing novel and much-needed information on the sources, uptake, and movement of microplastics in nearshore food webs.

**Yogita Warkhade**, Isaac Bigcraft, Laura Schaerer and Stephen M Techtmann, Michigan Technological University, Houghton, MI, USA. **Diversity of organisms encoding aerobic and anaerobic hydrocarbon-degrading genes in the Great Lakes.**

An oil spill is a growing concern in the Great lake. Through oil bioremediation, microorganisms in the aquatic ecosystem can degrade hydrocarbons by using alkane-degrading genes. Alkane hydroxylase is an enzyme commonly used by microorganisms. Previous studies showed the phylogenetic diversity of alkane hydroxylases in the Great Lakes. Alkane hydroxylases are only one type of hydrocarbon-degrading gene with a limited substrate range and are involved only in aerobic alkane degradation. Here we conducted a Metagenomic analysis on six sediment samples from Lake Superior, Lake Michigan, Lake Huron, and Canyon Lake to determine the diversity of alkane hydroxylases and other hydrocarbon-degrading genes. We assembled Metagenome Assembled Genomes (MAGs) from the datasets and annotated hydrocarbon degrading genes using the CANT-HYD hidden Markov models. These models will identify genes involved in the biodegradation of alkanes and aromatics under aerobic and anaerobic conditions. We also classified the taxonomy of the MAGs. Our results confirm the presence of hydrocarbon-degrading genes in sediment samples across the Great Lakes. These genes were mainly found in MAGs classified as Flavobacteria, Proteobacteria, Actinobacteria, Chloroflexi, and Thaumarchaeota. Much of the work on the diversity of hydrocarbon-degrading genes has focused on marine and groundwater environments, leaving freshwater systems relatively unstudied. This work will expand our understanding of hydrocarbon-degrading microbial metabolisms in the Great Lakes.

**Les Warren**[1], Edward Rutherford[2], David B. Bunnell[3], Paris D Collingsworth[1,4], Steve Pothoven[5] and Tomas O Hook[1,4], [1]Purdue University, West Lafayette, IN, USA, [2]NOAA GLERL, Ann Arbor, MI, USA, [3]USGS Great Lakes Science Center, Ann Arbor, MI, USA, [4]Illinois-Indiana Sea Grant, West Lafayette, IN, USA, [5]NOAA GLERL, Muskegon, MI, USA. **Quantifying the importance of alternative nursery habitats to alewife recruitment in Lake Michigan.**

The Lake Michigan alewife (*Alosa pseudoharengus*) population is a key component of the lake's food web and supports recreational fisheries targeting salmonine species. Alewife spawn in multiple habitats in Lake Michigan including drowned-river mouth lakes (DRMLs), tributaries, and nearshore environments. Due to its large volume compared to other habitats, the nearshore region of Lake Michigan has been considered the primary source of alewife recruits. However, Lake Michigan has undergone substantial changes including lower productivity and increased water clarity in recent years. In the past, habitats like DRMLs provided warm, high turbid environments, with relatively high prey availability. Thereby, young alewife in these environments experience relatively early hatch dates, high growth rates and high survival. To assess if these alternative nursery habitats are now producing a greater share of alewife recruits, we replicated a previous study consisting of weekly sampling of larval fish in Muskegon Lake and the nearshore waters of Lake Michigan adjacent to Muskegon Lake during the summer of 2021. Muskegon Lake had warmer surface temperatures, greater turbidity, and greater zooplankton densities than nearshore Lake Michigan. Larvae reared in Muskegon Lake also hatched earlier and had higher growth rates. These results remain consistent with the study performed 20 years earlier. We continue to compare the results of the two studies to evaluate the importance of these alternative nursery habitats in sustaining the alewife population in Lake Michigan.

**K Elise Watchorn**[1], Allison Waedt[1] and Kailey Carrière[1,2], [1]Environment & Climate Change Canada, Winnipeg, MB, Canada, [2]University of Manitoba, Winnipeg, MB, Canada. **Lake Winnipeg's nearshore: water quality and aquatic biota.**

Lake Winnipeg, the 10th largest lake in the world, has been relatively well-studied in its offshore regions. However, its nearshore -- which is ample thanks to a long shoreline and shallow lake depth, is rich with coastal wetlands, and is increasingly facing change from invasive species such as zebra mussels and hydrologic variability due to climate change -- has been comparatively under-studied. This talk will describe the development of the first aquatic monitoring program for Lake Winnipeg's nearshore areas, and present findings contributing to an improved understanding of water quality and the zooplankton community of this great lake.

**James M Watkins**[1], Anne E Scofield[2], Tom Hollenhorst[3], Sam Miller[4] and Lars G. Rudstam[1], [1]Cornell Biological Field Station, Bridgeport, NY, USA, [2]US Environmental Protection Agency, Chicago, IL, USA, [3]USEPA/ORD, Duluth, MN, USA, [4]EPA MED, Duluth, MN, USA. **Finescale vertical distribution of zooplankton in offshore Lake Ontario in 2018.**

Zooplankton in Lake Ontario cover a broad range of size and taxonomic groups that exhibit a diversity of life history strategies and environmental preferences. Vertical gradients of light and temperature are particularly important controls on distribution. Monitoring based on traditional net sampling provide only a coarse assessment of overall biomass and community composition. However, a finer scale understanding of the vertical variation of zooplankton is important for comparisons to the distribution of phytoplankton and planktivorous fish. During 2018, a Triaxus vehicle and V-fin equipped with a laser optical plankton counter (LOPC) were towed several times along a western and eastern offshore transect in Lake Ontario, undulating from 5 to 60 m depth along a 10 km path. These continuous transects supplemented a traditional lakewide net-based zooplankton survey. Zooplankton respond to both horizontal gradients such as thermal bar fronts in spring as well as vertical gradients such as summer stratification and deep chlorophyll maxima (DCM). Deep zooplankton layers initially align closely with the DCM, but persist into the fall despite weaker stratification and the complete dissipation of the DCM. These layers were consistently represented by deep calanoid copepods, while other taxa were limited to the warmer epilimnion.

**Ray H Watkins**, Michael J. Sayers, Robert A. Shuchman and Karl Bosse, Michigan Tech Research Institute, Ann Arbor, MI, USA. **Validation of ICESat-2 products in the Great Lakes: Bathymetry, attenuation, and particulate backscatter.**

Considering a changing climate, monitoring large bodies of water, such as the Laurentian Great Lakes in North America, can be challenging and costly. The bathymetry, the diffuse attenuation coefficient for downwelling irradiance ($K_d$), and the particulate back-scattering coefficient ($b_{bp}$) are important metrics in monitoring water quality of lakes and have been typically measured in two ways: 1) via in situ sampling campaigns which are expensive, time consuming, and have low spatial resolution and 2) via passive optical imagery which can have errors in excess of 50 %. Recently, ICESat-2, an active LiDAR based satellite, has proven effective in deriving the bathymetry, $K_d$, and $b_{bp}$ on the global oceans. However, validation of such metrics has never been done on satellite flyovers taken the same day as in situ measurements. Likewise, studies on freshwater environments have been limited. Here, we compare in situ data sampled on Lake Michigan and Big Glen Lake between August 13th and 14th, 2021 and results derived from an ICESat-2 flyover in the same region on August 14th, 2021. We find excellent agreement between the in situ values and the satellite derived values for all three metrics. This suggests that ICESat-2 and other, future LiDAR based satellites will be powerful tools in monitoring large, freshwater lakes.

**Meredith Watson**[1], Shuhuan Li[2], Roland I. Hall[1], Philippe Van Cappellen[2] and Fereidoun Rezanezhad[2], [1]University of Waterloo, Waterloo, ON, Canada, [2]Ecohydrology Research Group, University of Waterloo, Waterloo, ON, Canada. **Time trends in microplastics deposition to a reservoir in the urbanizing Grand River Watershed.**

Plastic pollution has become a widespread environmental hazard, raising concern for ecosystem degradation by microplastic particles (MPs). Research on MPs has been limited in Canadian freshwaters, and time trends remain largely unknown. Here we report changes over time in microplastic abundance and composition in a dated sediment core from Belwood Lake, a reservoir within the rapidly urbanizing Grand River Watershed (GRW). MPs were extracted from 1-cm thick intervals, and quantified and categorized by shape (fragment, fiber, bead). Since the 1960s, total concentrations have varied ~70-500 MPs/g dry sediment, with highest values in the early 1970s and since 2000. Fragments are the most common type, followed by fibers. Beads appeared in sediment deposited since 1990, which coincides with onset of commercial use. Next steps include analysis of the extracted MPs by LDIR spectroscopy to determine

temporal variation in size and composition of the particles, as well as analysis of a sediment core from a second reservoir in the watershed (Conestogo Lake). The findings will contribute to Canada's Plastics Science Agenda by generating new knowledge on changes over time in microplastics deposition within the largest, and rapidly urbanizing, watershed in southern Ontario.

**Wyatt Weatherson**, Carolyn Johns and Christopher Wellen, Toronto Metropolitan University, Toronto, ON, Canada. **Comparing and Evaluating Nutrient Offsetting Programs in Ontario.**

Nutrient offsetting strategies have increasingly been applied in North American watersheds to address excess nutrient (e.g., phosphorus) concentrations from point and non-point source discharges in surface waters within the Laurentian Great Lakes Basin and beyond, though we only report on offsetting programs within the Ontario, Canada jurisdiction. Informed by key informant interviews with public servants and offsetting program participants, as well as scholarly and grey literature, we develop an evaluative framework and assess the performance of four nutrient offsetting programs in Ontario, Canada. While existing efforts to offset phosphorus discharge by non-point sources have not had detectable reductions in stream loadings, such shortcomings could be addressed if nutrient offsetting program design and implementation becomes increasingly proactive, and transitions away from being reactive, such as in response to increased discharge from point sources (e.g., wastewater treatment plants). We identify several opportunities for improvement for future iterations of nutrient offsetting programs in Ontario's watersheds relating to the reliance on highly imprecise estimates of BMP effectiveness, lack of practical testing or monitoring to assess installed performance, and inconsistent application of regulatory requirements.

Dylan Roberts, Iris Koch and **Kela Weber**, Environmental Sciences Group - Royal Military College of Canada, Kingston, ON, Canada. **Identifying Ontario groundwater PFAS sources as a threat to Laurentian Great Lakes.**

Since their creation, per- and polyfluoroalkyl substances (PFAS) have been used in a wide breadth of industrial and commercial processes from highly specialized applications to more general usage scenarios. Despite the well-known nature of PFAS applications within specific industrial sectors, little is known about the number of facilities that may have acted or be acting as point sources for PFAS released to the environment. This research seeks to provide an estimate for the number of potential PFAS point sources in Ontario. Of the 40 industrial sectors identified, six have been evaluated to provide estimates and will be presented (landfills, wastewater treatment plants, automotive manufacturing, metalworks facilities, fuel and distribution sites, paper manufacturing). Estimates were obtained using decision tree frameworks developed for each individual industry. In total, over 3200 individual facilities were identified as possible PFAS point sources. 1482 individual sites were concluded to be likely point sources of PFAS and a further 1734 sites were considered as possible point sources. This presentation will cover the methodology used, showcase the current/resulting GIS and give a general overview of the 543 facilities identified as possible PFAS sources within 10 km of the Great Lakes.

**Caroline Weidner**[1], Sherry L Martin[2], Jay Zarnetske[1], Amelia Grose[1] and Arial Shogren[3], [1]Michigan State University, East Lansing, MI, USA, [2]US Geological Survey, Lansing, MI, USA, [3]University of Alabama, Tuscaloosa, AL, USA. **Subcatchment Spatiotemporal Solute Trends in a Wetland-Dominated Catchment in Michigan, USA.**

The presence of wetlands nested in a catchment can influence the biogeochemical storage and release of carbon and nutrients into the stream network, leading to dynamic source and sink behavior over space and time. However, we have limited understanding of how temporal and spatial hydrologic variability impact the contribution of wetlands to the stream network across a catchment. To address this knowledge gap, we conducted repeated synoptic sampling at 28 subcatchments across a gradient of wetland coverage in the Augusta Creek catchment of southwest Michigan, USA. To capture temporal trends, we sampled every

2-3 weeks beginning in October 2021. At each site, we sampled a suite of solutes, including dissolved organic carbon (DOC). We then calculated novel ecohydrology metrics which indicate the spatial scale, direction, and stability of spatial patterns of water chemistry, including spatial variance collapse, subcatchment leverage, and spatial persistence of biogeochemical conditions. Our findings show seasonal variation in DOC patterns across different subcatchments. Spatially, we found that larger subcatchments with intermediate wetland coverage close to the main stem act as stronger DOC sources and sinks, while smaller subcatchments with high wetland coverage are weak sources. Overall, our study shows that in this wetland-dominated Michigan catchment, biogeochemistry patterns vary across season, location in the catchment, and wetland coverage.

**Chris Grant Weisener**, Great Lakes Institute for Environmental Research, University of Windsor, Windsor, ON, Canada. **Improving our understanding of Environmental Stress in Freshwater-watersheds impacted by hydrocarbons.**

In recent years the application of molecular approaches to identify the microbial microbiome response to anthropogenic stress has advanced considerably. The activity of these microorganisms can directly impact the chemical conditions in both surface and subsurface water column and within contaminated sediments. It is still not apparent whether hydrocarbons impacted environments will disrupt the fate of nutrients and contaminants alike. Questions arise such as: (1) What are the baselines or reference systems that can be used? (2) What indices can be used to study the long-term and short-term controls on the mobility, cycling, and bioavailability of organic contaminants? In these cases, biogeochemical systems will determine the direction and onset of specific metabolic pathways as defined by their favorable thermodynamic outcome, an issue for most bioremediators (i.e., microorganisms). Secondly, the degree of chemical alteration can be directly linked to the proportion of their biological activity. In this presentation, contrasting case studies from hydrocarbon stressed freshwater habitats will be discussed. The focus will be on identifying and linking physicochemical processes to microbial community function using emerging omics for geochemical applications and ascertaining novel hydrocarbon contaminant bioindicators.

**Christopher Wellen**[1], Kelly Biagi[2], Alexander Pardy[1], Melisa Luymes[3], Bryant Serre[4], Bhaswati Mazumder[1], Ryan J Sorichetti[5] and Janis L Thomas[5], [1]Toronto Metropolitan University, Toronto, ON, Canada, [2]Brock University, St. Catherines, ON, Canada, [3]Headlands ag-enviro solutions, Guelph, ON, Canada, [4]McGill University, Montreal, QC, Canada, [5]Ontario Ministry of the Environment, Conservation and Parks, Toronto, ON, Canada. **Assessing the phosphorus mass balance of eleven headwater agricultural catchments in Southern Ontario.**

Eutrophication in the forms of nuisance and toxic algal blooms, shoreline fouling, and hypoxia is a major water quality concern in all of the lower Great Lakes. One of the main drivers of eutrophication is excessive phosphorus inputs to the lakes, and one of the main sources of phosphorus is runoff from agricultural nonpoint sources. Regional scale statistics have shown that phosphorus has historically been applied in excess of plant needs in Southern Ontario, though more recent applications have been much closer to plant needs. However, the finer scale variability of the phosphorus mass balance is not well understood. This research quantifies the phosphorus mass balance for eleven small agricultural watersheds in Southern Ontario using information collected from the Agri-Model survey of 160 farmers. The results reveal significant variability in the mass balance of phosphorus, with five of eleven watersheds running a negative P mass balance. The remainder ran a positive mass balance, but ranging widely, from 3.9 to 37.5 kg P/ha. Factors increasing the amount of phosphorus applied in excess of crop needs were examined, and areas with high manure production were often but not always areas with a high phosphorus mass balance. The results of this study help guide environmental policies by highlighting which parts of the landscape are likely increasing in phosphorus storage and suggesting why.

**Mathew Wells**[1], George Lu[2] and Robert E Hecky[3], [1]University of Toronto, Toronto, ON, Canada, [2]University of Toronto Scarborough, Toronto, ON, Canada, [3]formerly University of Minnesota-Duluth, Kitchener, Canada. **Intrusions of sediment laden rivers into density stratified water columns is a source of mixing in lakes.**

When a sediment laden river flows into a stratified water body, the water mass can either intrude as an overflow, interflow or underflow, depending upon the density contrast. Different modes of sediment driven convection occur in each case. For the case of overflows, convective sedimentation occurs beneath the plume, whereby sediment rich plumes rapidly transport fine materials to depth. If underflow of dense sediment laden waters initially occurs, then after sediment has been deposited, the light interstitial material can subsequently loft and potentially mixes the entire water column. For an interflow, both lofting and sediment driven convection can occur above and below the pycnocline. Laboratory experiments were used to describe the vigour of convection. These observations are also applied to predict how a turbidity current could lead to lofting and possible overturn of the stratification of Lake Kivu, a large meromictic lake between Rwanda and the Democratic Republic of the Congo.

**Amanda Welsbacher**, Ryan Sheehan, Abigail Melendez, Hannah Phillips, Ivor Knight and Matthew Gruwell, Penn State Behrend, Erie, PA, USA. **Collection of Nitellopsis obtusa and Determination of eDNA Signal Detection Limit.**

Nitellopsis obtusa is a macro-algae native to Eurasia, brought to the Great Lakes through ballast water of commercial ships. This experiment's objective was to collect and identify N. obtusa in the PA waters of Lake Erie and determine the detection limit of N. obtusa eDNA. N. obtusa was identified by its white star-shaped bulbils, orange antheridia, and identification by Sanger Sequencing. Two experiments were completed, one with N. obtusa samples of 1.0 g, 2.0 g, and 5.0 g, the second with 0.08 g, 0.4 g, and 0.8 g placed in jar with 800 mL of lake water in triplicates. Samples were taken once a week for three weeks using flat filter housings, a Masterflex pump, and tubing. Filters were subjected to a DNA extraction protocol known to successfully obtain eDNA signal from water samples and eDNA signal was examined using a qPCR protocol. qPCR analysis indicated that N. obtusa samples of 1.0 g, 2.0 g, and 5.0 g in 800 mL of water had insignificant differences in PCR signal (CQ values ranging 26-30), and N. obtusa samples of 0.8 g and less had limited detection (CQ values from 34 to not detectable). This experiment demonstrated that the detection limit for N. obtusa eDNA is 1.0 g per 800 mL of water, much higher than similar trials using aquatic invertebrates. The results are consistent with preliminary field trials in which N. obtusa eDNA was not recovered from water samples taken from locations known to have live populations of the plant.

**Brittany Welsh**[1], Julian Aherne[1], Andrew M Paterson[2], Huaxia Yao[2] and Chris McConnell[2], [1]Trent University, Peterborough, ON, Canada, [2]Ministry of the Environment, Conservation and Parks, Dorset, ON, Canada. **A particle balance approach to the fate of microplastics in background headwater lake catchments.**

Microplastics are pervasive contaminants of concern, but field studies quantifying microplastic fate and distribution at the catchment level remains seldom. In the current study, the flux of microplastics (mp) were quantified during a 12-month period for three background headwater lake catchments in Muskoka-Haliburton, Ontario. A particle balance approach was used incorporating inputs from atmospheric deposition and inflows against outflows and sedimentation to lakes. The results showed that atmospheric deposition had the highest daily microplastic flux rate (3.95–8.09 mp/$m^2$/day) compared to the inflow streams (2.21–2.34 mp/$m^2$/day), suggesting that it is the dominant source of microplastics to background regions. Approximately 44–71% of the deposited microplastics were retained in the terrestrial catchment, and a further 30–49% of the microplastics in the stream inflow were retained in the study lakes. Given that the output flux ranged from 1.57–2.98 mp/$m^2$/day in the sediment and 1.18-1.66 mp/$m^2$/day in the outflow stream, the microplastic residence time was estimated to be between 3 and 12 years for the lakes suggesting that lakes are a reservoir for microplastics. Fibres were the dominant shape identified in

atmospheric deposition, stream water and lake water; however, in lake sediment, there was a higher proportion of fragments. For all sample media, polyethylene terephthalate (20%) was the dominant polymer identified followed by polypropylene (18%) and polyamide (14%).

**D V Chip Weseloh**[1], Eildert Beeftink[2], Sean Bellaviti[2], Connor Smith[2], Patricia Holonylo[2] and Makail Johannesson[2], [1]Canadian Wildlife Service, Toronto, ON, Canada, [2]Independent, Toronto, ON, Canada. **The spring re-occupation of "The Spit" by 25,000+ gulls and cormorants – How do they do it?.**

Tommy Thompson Park (TTP) is home to > 25,000 breeding Ring-billed Gulls and Double-crested Cormorants. Our goal was to document the little known process of spring colony re-occupation, i.e., how do these two species, who nest within pecking distance of their neighbours, return to their nest site: is it a quick or slow process, do they do it individually or en masse? The gulls arrive back in Toronto in mid-late February and initially occupy the ice in the Outer Harbour. They start to visit their colony site (Peninsulas A and B) en masse within 2 weeks but depart each evening to roost out on the lake.... until early May. For eight weeks, every morning, before sunrise, they congregate on the water, 3-400m offshore and vocalize. Eventually, they fly up in a whirling swirling aerial display that culminates when 5,000 gulls land, en masse, on a small area of the colony and scurry to their territories. The aerial display and the deafening screaming and beating of wings defies imagination and will be shown on video. Cormorants, however, are much calmer, have no aerial displays and vocalize very little. They arrive back in Toronto by mid-March. Initially their numbers are few. Most simply fly over their colony site but some land in the embayments, within 100m of their nests, immediately. By March 31st, small numbers of cormorants repeated land in water near their nests, walk and fly up to their nests, sit down in them and commence sky-pointing. More behavioural descriptions during the presentation. This work is fundamental to potentially developing new viewing opportunities for the public at TTP.

Shane DeSolla[1], **D V Chip Weseloh**[2], Kimberley Hughes[3], Karen McDonald[4], Andrea Chreston[4] and David Moore[5], [1]Science and Technology Branch, ECCC, Burlington, ON, Canada, [2]Canadian Wildlife Service, ECCC, Toronto, ON, Canada, [3]Broadwing Biological Consulting, Port Perry, ON, Canada, [4]Toronto and Region Conservation Authority, Vaughan, ON, Canada, [5]Canadian Wildlife Service, ECCC, Burlington, ON, Canada. **Colonial Waterbirds at Tommy Thompson Park (TTP): Nest numbers and contaminant levels in eggs.**

The objectives of this study were to monitor two avian features at TTP: 1. the annual number of nests of all colonial waterbirds, and 2. contaminant levels in eggs of Herring Gulls and Double-crested Cormorants; two of the metrics used in assessing Beneficial Use Impairments in this Area of Concern. Nine species of colonial waterbirds have nested at TTP since 1973. Their current number of nests and whether they have increased, decreased or been stable (I,D,S) in the last three years (or when last counted) are: Double-crested Cormorants (8,860 D), Ring-billed Gulls (4,970 S), Common Terns (127 I), Herring Gulls (3 D), Black-crowned Night Herons (0 D), Great Egrets (0 D) and Caspian Terns (0 S). Two former nesting species have not nested at TTP for several years: Great Black-backed Gull (which seldom nests in western Lake Ontario) and California Gull (which is well out of its range in southern Ontario). Contaminant levels in Herring Gull and cormorant eggs were assessed at 15 sites throughout the Great Lakes, including TTP in 2018-19. Concentrations of nine legacy contaminants were combined to produce a Cumulated Total Sum Concentration; values from TTP scored 2nd highest in gull eggs and 3rd highest in cormorant eggs. Total Toxic Equivalents, mercury and PFOs were also measured in both species at all 15 sites. Gull and cormorant values from TTP scored 2nd and 1st in TEQs, 4th and 7th in mercury and 1st for both species in PFOS, respectively. Temporal trends in contaminants from TTP will also be given.

**Molly Wick**[1], Joel C Hoffman[2], Lucinda B. Johnson[3] and Deanna Erickson[4], [1]University of Minnesota Duluth, Duluth, MN, USA, [2]USEPA ORD Great Lakes Ecology and Toxicology Division, Duluth, MN,

USA, [3]NRRI, University of Minnesota Duluth, Duluth, MN, USA, [4]Lake Superior National Estuarine Research Reserve, Superior, WI, USA. **How do social factors influence coastal cultural ecosystem services? A case study in the St. Louis River Estuary.**

Cultural ecosystem services (CES) assessments have the potential to guide environmental decision-making and increase equitability of outcomes for communities. However, the influence of social factors on CES is poorly understood and this limits their practical applications. To help address this gap, we designed a mixed methods study to identify environmental and social factors that affect CES experiences in the St. Louis River Estuary of Lake Superior. The objective of this research is to understand how place and personal identity interact to mediate the CES experiences of a community. The Waterway Benefits Survey targeted a diverse sample of over 700 participants and collected quantitative data on CES that respondents experienced in the past year, CES experience locations, barriers to CES experiences, and participant sociodemographics. Analysis focuses on how sociodemographics (age, gender, race, income) are associated with participants' CES experiences. Semi-structured interviews will be conducted with a subset of survey participants to help understand how place and identity interact to influence CES. Interviews will explore factors that enabled or prevented CES experiences and how sociohistorical factors influence CES experiences. Based on the results, we will identify management interventions to increase supply, quality, and equity of CES benefits. Results will be specific to the St. Louis River estuary but will be transferrable to similar social-ecological systems and will provide a holistic framework to measure and understand CES elsewhere.

**Kathleen Colin Williams**[1], Joel C Hoffman[2], Sebastian Paczuski[3] and Julia Witts[4], [1]USEPA Office of Research and Development, Duluth, MN, USA, [2]USEPA ORD Great Lakes Ecology and Toxicology Division, Duluth, MN, USA, [3]Oak Ridge Associated Universities, Duluth, MN, USA, [4]USEPA Office of Research and Development, Great Lakes Toxicology and Ecology Division, Duluth, MN, USA. **Recognizing different community visions and outcomes in community revitalization in Great Lakes Areas of Concern.**

There is growing recognition of the importance of identifying and characterizing local variations in ecological and community revitalization in Great Lakes Areas of Concern (AOC), where sediment remediation and habitat restoration activities are ongoing. Because of these local variations in geography, culture, opportunity, and capacity, revitalization can look different in each AOC depending on the water resources, existing businesses, existing or proposed trails and green space, and perceptions of those resources. Thus, it is important to recognize how indicators of revitalization may be arranged at the site level, and how community visions and capacity may vary. In some places, revitalization may look like people kayaking, walking on trails, or increased visiting, photography, or nature viewing. In other places, revitalization may look like increased tourism, new shops, or new or improved marinas. To illustrate how revitalization might differ in two different places with remediation and restoration projects, this presentation will share results from recent field work in Superior, WI and Cuyahoga Falls, OH. Recognizing different local social conditions is especially important for identifying and characterizing environmental justice concerns and remedies. The presentation will compare project details, local context, and revitalization indicators and conclude with recommendations for how to recognize and nurture social and ecological revitalization. *The contents of this abstract neither constitute nor necessarily reflect USEPA policy.*

**Olivia Williams**[1], Karen Alofs[2] and Sally Petrella[3], [1]University of Michigan, Ann Arbor, MI, USA, [2]University of Michigan, School for Environment and Sustainability, Ann Arbor, MI, USA, [3]Friends of the Rouge, Plymouth, MI, USA. **A Comparison of Seining and Electroshocking in the Rouge River, MI.**

The Rouge River, an EPA Area of Concern, in southeast Michigan is considered a highly degraded river. Varied watershed restoration projects have occurred over the last several decades. These projects have improved the abiotic components of the river, but improvements to the biotic communities are uncertain. Friends of the Rouge (FOTR), a non-profit committed to restoring the river, has been monitoring fish

communities since 2012 by seining. The largely volunteer monitoring program has sampled > 135 sites in the watershed and identified over 60 fish species. Electroshocking is considered the preferred sampling method for evaluating stream fish communities. However, concerns, including costs and safety, have prohibited FOTR from electroshocking in the past. In summer 2022, University of Michigan assisted FOTR community scientists in electroshocking > 50 sites in the watershed to compare the methods. We assessed the differences between the electroshocking data and seining data. We found few differences in species richness, community dissimilarity, and the presence of tolerant and intolerant species across sites. FOTR is the only organization consistently monitoring in the Rouge and we find that seining has several advantages for their program and produces reliable assessments.

**Rob Wilson** and Brian K. Ginn, Lake Simcoe Region Conservation Authority, Newmarket, ON, Canada. **20 years of monitoring the fish populations in the tributaries of the Lake Simcoe watershed.**

Over the last two decades the Lake Simcoe watershed has continued to experience environmental stressors related to chloride, nutrient loading, invasive species and climate change. This presentation will summarize 20 years of fisheries monitoring in Lake Simcoe tributaries examining the response of fish populations to increases in tributary chloride concentrations (winter de-icing salt application), phosphorus concentrations, the introduction and spread of round gobies, and warming water temperatures due to climate change. With many similarities to other urbanized Great Lakes tributaries the status and trends of Lake Simcoe tributary fisheries has a direct comparison to these riverine systems and could have potential relevance to their fisheries management strategies.

**Victoria Wisniewski**, Lyndsay Cartwright, Calvin Hitch and Krista M. Chomicki, Toronto and Region Conservation Authority, Vaughan, ON, Canada. **High-resolution temporal chloride patterns and contributions from two urban creeks on Lake Ontario's north shore.**

Long-term analysis of grab chloride samples in the Greater Toronto Area (GTA) has identified that chloride concentrations are on the rise exceeding chronic (and sometimes acute) Canadian water quality guidelines for the protection of aquatic health, particularly in the heavily urbanized Etobicoke and Mimico watersheds. While grab samples suggest concentrations are increasing, they are unable to detect or provide information on episodic concentrations which can be much higher than detected by grabs and are too expensive to collect and analyze with high temporal resolution. This talk will highlight data collected using continuous conductivity sensors as a chloride surrogate to look at chloride patterns in the watersheds and entering Lake Ontario from two of the GTAs heavily urbanized watersheds. Episodic concentration ranges, duration of Canadian water quality guideline exceedances, and loading estimates to Lake Ontario will be highlighted providing insight to whether grab samples are underestimating our temporal increases in chloride.

**Michael Wright**[1], Teresita Porter[1], Tamanna Kohi[1], Raegan Mallinson[2], Victoria Carley Maitland[1], Donald Baird[3] and Mehrdad Hajibabaei[1], [1]University of Guelph, Guelph, ON, Canada, [2]Living Lakes Canada, Nelson, BC, Canada, [3]University of New Brunswick, Fredericton, NB, Canada. **A STREAM-lined approach to breaking barriers in community-based water monitoring.**

The STREAM (Sequencing the Rivers for Environmental Assessment and Monitoring) project joins together standardized training and sampling, community-based monitoring, and eDNA metabarcoding for the large-scale, rapid identification of freshwater benthic macroinvertebrates in routine environmental assessment. Since the establishment of STREAM in 2019, over 300 community participants have been trained by Living Lakes Canada and over 1500 samples have been collected and analyzed across Canada. Standardized and accessible sampling methods using the Canadian Aquatic Biomonitoring Network (CABIN) framework allow STREAM participants to generate a critical mass of data needed to close information gaps within their communities, while helping to build a clear picture of watershed health in

Canada. Using STREAM's approach, the scientific data bottleneck for identifying freshwater macroinvertebrates can be eliminated, allowing for rapid dissemination of watershed biodiversity reports with a target turnaround time of two months. Community groups can then use STREAM reports to elevate their collective work in aquatic ecosystem management, conservation, and restoration. We will summarize STREAM's methodologies and showcase the power of community-based monitoring in case studies that highlight some of the outcomes and successes from watershed groups, NGOs, and Indigenous communities within the Great Lakes Basin.

**Chin H Wu**[1] and Yuli Liu[2], [1]University of Wisconsin-Madison, Madison, WI, USA, [2]School of Marine Sciences, Nanjing University of Information Science and Technology, Nanjing, China. **Occurrences of meteorologically induced water level oscillations in a semi-enclosed basin, Lake Superior.**

Meteorologically induced water level oscillations (MIWLO), commonly seen as meteotsunamis or seiches, have been recognized as one of coastal hazards worldwide. In this talk, occurrence of meteorologically induced water level oscillations (MILWO) inside a semi-enclosed basin, different from an open coast, is characterized. Based on 3-year water level observations in the Chequamegon Bay (CB) of Lake Superior, identified MIWLO events were associated with storms types of storm drivers. Results show that MILWO events tended to immediately respond to wind-dominated storms and evolve into large wave heights. In contrast, MILWO events occurred several hours after atmospheric pressure-dominated storms. Based upon recurrence interval analysis, MIWLO events due to pressure-dominated storm were found to occur more frequently. Detailed hydrodynamic modeling reveals the occurrence of pronounced MIWLO at 2 ~ 2.2 hours. These distinct periods are caused by both amplification due to the resonant modes of the bay and minimum damping due to large quality factor in a semi-enclosed bay. Overall, this study suggests that the physical environment of semi-enclosed basin (e.g., harbors or natural bays) in Lake Superior can be of concerns for MIWLO hazards.

# X

**Qianqian Xiang**[1,2], Peng Wang[2], Qinqin Li[2], Hui Yan[2], Xuexiu Chang[1] and Liqiang Chen[2], [1]College of Agriculture and Life Sciences, Kunming University, Kunming, China, [2]Institute of International Rivers and Eco-security, Yunnan University, Kunming, China. **Metabolic profiling of polyethylene microplastic toxicity in *Daphnia magna*.**

The ecotoxicity of microplastics has been concern because of their potential risk to the ecological environment and human health. Although the adverse effects of microplastics in *Daphnia magna* have been widely reported, their toxic mechanisms remain unclear. The aim of this work is thus to elucidate the mechanism of toxicity in *D. magna* following exposure to two sizes of polyethylene microplastics (20 μm, MPs-20, and 30 μm, MPs-30) using metabolomics based on non-targeted liquid chromatography and mass spectrometry. The results revealed that MPs-20 and MPs-30 induced 88 and 91 differentially expressed metabolites (DEMs) in *D. magna*, respectively. Among the DEMs, 75 were shared metabolites induced by two sizes of microplastics. These metabolites were mainly involved protein digestion and absorption, purine metabolism, and central carbon metabolism pathways. Nevertheless, MPs-20 specifically induced 13 DEMs, which mainly involved phospholipid metabolism process. MPs-30 specifically induced 16 DEMs, which mainly involved energy metabolism process. Further examination revealed that both MPs-20 and MPs-30 significantly decreased the heart rate of *D. magna*. These results suggested that microplastics induced lipid and energy metabolism disorders, which affected the heart rate of *D. magna*. The findings of this work provided novel perspectives for understanding the toxic mechanism of microplastics in *D. magna*.

# Y

**Adam Jiankang Yang**[1], Jason Olsthoorn[2] and Mary-Louise Timmermans[1], [1]Yale University, New Haven, CT, USA, [2]Queen's University, Kingston, ON, Canada. **Enhanced sedimentation in particle-laden flows with and without velocity shear.**

The vertical transport of sediment from particle-laden overflows and interflows in lakes and oceans can be enhanced by a settling-driven convective instability. We conduct direct numerical simulations to investigate the vertical transport of sediment in the presence and absence of horizontal velocity shear. We show how this transport is determined by a competition between the growth of the settling-driven convective instability (Rayleigh-Taylor, RT) and the stratified shear instability (Kelvin–Helmholtz, KH). In the absence of shear, the RT instability drives the enhanced vertical sediment transport; this effect increases when the Stokes settling velocity of the particles is faster, and decreases when the stratification is stronger. The presence of velocity shear inhibits the vertical transport of sediment. When the shear is strong, the KH instability grows rapidly and suppresses the RT instability. We explore the parameter space of these regimes and interpret their physics.

**Kunyu Yang**[1], Nathaniel Marshall[2], Reagan M. Errera[3], Casey M Godwin[4] and Subba Rao Chaganti[4], [1]University of Michigan, Ann Arbor, MI, USA, [2]Stantec, Columbus, OH, USA, [3]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, USA, [4]Cooperative Institute for Great Lakes Research, University of Michigan, Ann Arbor, MI, USA. **Role of abiotic and biotic factors on microbial community dynamics during cyanobacterial harmful algal blooms.**

The microbial community abundance and diversity determine the productivity of an aquatic lower-food web. However, the microbial community composition is prone to change concerning emerging environmental factors. Such as elevating anthropogenic nutrient loading and climate change, representing abiotic factors; interspecies relationships in algal bloom season, representing biotic factors. These factors can synergistically lead to a major shift in the dynamics of the microbial community with decreased abundance and diversity, and hence, therefore, impair ecosystem productivity. This ecological consequence could be detrimental to the sustainable development of fisheries as it depends on a healthy lower food web. To comprehend the roles of these factors, we collected water samples and measured abiotic factors such as nutrients and other environmental factors from western Lake Erie (WLE) during pre/peak/post-bloom seasons. For microbial community analysis, 16S/18S rRNA metabarcoding sequencing was performed on DNA extracted from water samples. The change in bacterial alpha and beta diversity was observed in association with the peak cyanobacterial bloom. Alpha diversity sharply declined after the peak bloom and slowly recovered during post-bloom. Although the pattern was similar across the sites in alpha diversity higher alpha diversity was noticed in sites close to the Maumee River mouth. Our study revealed the critical roles of abiotic and biotic factors in the dynamics of the aquatic microbial community during cyanobacterial harmful algal blooms.

**Alyssa Yaple**[1], Eric Saas[1], Emily Rugg[2] and Kara Tarallo[3], [1]Ohio Department of Natural Resources, Columbus, OH, USA, [2]Ohio Department of Natural Resources, Lakeside-Marblehead, OH, USA, [3]Ohio Department of Natural Resources, Oregon, OH, USA. **Students taking action to improve Lake Erie's water quality.**

Through feedback from the Ohio Department of Natural Resources (ODNR) Conservation Teen Advisory Council, ODNR found students, particularly in Northwest Ohio, had a negative perception of Lake Erie's water quality. Students cited harmful algal blooms (HABs) that threaten drinking water and the health of people and wildlife. Avoiding Lake Erie, as many of these youth do, is not the solution. Doing nothing to reverse this mindset poses a danger to the future health of Lake Erie and our freshwater systems which are vital to the people and industry who need these important natural resources. In response, ODNR

created the H2Ohio Students Take Action (STA) program thanks to a grant from the Great Lakes Restoration Initiative (GLRI). H2Ohio is Ohio Governor Mike DeWine's data-driven water quality plan. STA provides free experiential learning opportunities and guided kayak experiences so students grades 6-12 in Northern Ohio can paddle through the very waters they learn about. Program outcome goals are to foster interest in citizen science and enable students to use what they learn to develop ideas that positively impact water quality. STA projects have included water testing, macroinvertebrate surveys, plant and wildlife inventories, raising and releasing native fish, rearing and planting native wetland plants, installing water level gages, and more. Data is recorded in GLOBE, iNaturalist, and with Ohio's Scenic Rivers program. In the programs first year, 2048 students across 41 schools/organizations were reached including 41% of students identified as disadvantaged.

**Nicholas Yeager**[1], Kailee Schulz[1], Alden Tilley[1] and Peter C Esselman[2], [1]United States Geological Survey, Ann Arbor, MI, USA, [2]U.S. Geological Survey, Great Lakes Science Center, Ann Arbor, MI, USA. **Round Goby Catch Efficiency Using Down Looking Still Imaging.**

Since their introduction to the Laurentian Great Lakes in the late 1980's, round goby Neogbius melanostomus have become a species of interest due to their adverse effects on native species and influence in lake dynamics as a common prey species. Lake-wide biomass estimates largely rely on bottom trawls, which have several limitations including decreased catch rate over high structure substrates. Round goby favor high structure bottom features, such as boulder and cobble, resulting in a significant under-representation of round goby in bottom-trawl surveys. Camera based methodologies, delivered via autonomous underwater vehicles (AUV's) or remote operated vehicles (ROV's), operate above the lakebed and are not limited by substrate. As round goby are known to take advantage of their physical environment for concealment and protection, we examined the efficacy of these digital surveys. To test the efficiency of camera-based methods, we designed microcosm enclosures containing a set number of round goby. We estimated the mean abundance of round goby visible to a dedicated camera across time and between sand and cobble substrates. More round goby were captured with the camera in the sand enclosure compared to the cobble enclosure. The effectiveness of the camera system increased during the day in fine substrate, but was more efficient in coarse substrate at night. These results can improve the accuracy of digital survey abundance estimates and add known benefits and limitations of underwater camera surveys.

**Mourine Yegon**, Augustine Sitati and Frank Onderi Masese, University of Eldoret, Eldoret, Kenya. **Elevation and landuse as drivers of macroinvertebrate functional composition in afrotropical streams.**

Lakes are largely influenced by streams feeding into them. As integrators of the effects of landuse practices within their catchments, streams can help in the diagnosis of the environmental health of the landscapes that they drain, as changes in the landscape is reflected in the resident biota. Macroinvertebrates occupy important roles in aquatic ecosystems by acting as bioindicators of water quality. The catchment area of the Nzoia river which drains into Lake Victoria, Africa's largest lake, is experiencing deforestation and expansion of agricultural practices. This study contributes to the understanding of biological-physical interactions in river catchments by investigating water physico-chemistry and the functional structure of macroinvertebrates in twenty sites within forested and agricultural areas, from high to low elevations. Significant spatial variation was observed in total suspended solids, coarse particulate organic matter, temperature and conductivity across elevational gradients and landuse types. Higher shredder biomass and abundance occurred in forested streams in higher elevations than in low elevation agricultural streams. Landuse played a predominant role in structuring communities and should be a focus in conservation planning in this region.

**Ben Young**, NEW Water, Green Bay, WI, USA. **Soil P Values Pre and Post BMP Implementation and Effect on Water Quality in Wisconsin Agricultural Watershed.**

Excessive sediment and nutrients, from point and non-point sources, have historically degraded the Bay of Green Bay, leading to dangerous algal blooms, hypoxic zones with depleted oxygen and water quality impairments. The Wisconsin DNR allows point sources, such as NEW Water, the brand of the Green Bay Metropolitan Sewerage District, alternative options in the form of watershed Adaptive Management for effluent regulatory compliance. In late 2013, NEW Water launched a pilot project to test the feasibility of Adaptive Management through watershed conservation in the small, predominately agricultural watershed of Silver Creek. Flow, water quality, biological monitoring and soil sampling began in 2014 to characterize baseline watershed conditions before the widespread implementation of best management practices (BMPs). Soil samples were collected on 108 agricultural fields throughout Silver Creek both pre and post implementation. Over the next 8 years, both operational (over ~600+ acres/year) and structural (388 acres) BMPs were implemented throughout the Silver Creek sub-basin. Soil-P results vary among agricultural fields, but overall the field level phosphorus throughout the watershed improved over the course of the pilot project. Soil P values before and after BMP implementation will be discussed, as well as potential effect on in-stream water quality changes. Experiences gained from the pilot project will be leveraged by NEW Water to guide larger scale Adaptive Management for the next 20 years in neighboring watersheds.

**Joelle Young**[1], Claire Holeton[1], Brian K. Ginn[2] and Hamdi Jarjanazi[1], [1]Ontario Ministry of the Environment, Conservation and Parks, Toronto, ON, Canada, [2]Lake Simcoe Region Conservation Authority, Newmarket, ON, Canada. **Update on Lake Simcoe's Water Quality and Open-water Lower Food-web: 1980 to 2022.**

Lake Simcoe has been experiencing significant changes to its ecosystem over the past two centuries from local and global stressors. Signs of stress became apparent in the 1970s, when high nutrient loads led to low dissolved oxygen and cold-water fish recruitment failure. In the 1980s, actions were initiated for reducing nutrient loading, such as the diversion of sewage from two major cities. These efforts were followed by improvements in water quality, particularly in dissolved oxygen; however, over the past few decades, global stressors have emerged that are changing how the ecosystem functions. For example, warming air temperature has increased the duration of thermal stratification and the temperature of the water, and the lake has had several invasions that appear to be rewiring its food web. Starting in the mid-1990s, the spiny water flea became established, which was followed shortly thereafter by the zebra mussel, and approximately 15 years later by the quagga mussel, Starry stonewort, and Round Goby. This presentation will provide an update on Lake Simcoe's lower open-water food web and water quality trends through 2022, and will highlight projects that are underway that have been designed to better understand this increasingly complex ecosystem.

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**Sophia A. Zamaria**[1] and George B. Arhonditsis[2], [1]University of Toronto, Toronto, ON, Canada, [2]Ecological Modeling Laboratory, Department of Physical and Environmental Sciences, University of Toronto, Toronto, ON, Canada. **Comprehensive calibration of a SWAT model in the Lake Erie basin: Iterative calibration of submodels.**

The SWAT model is one of the most widely used watershed models for water resource management and is comprised of submodels which can be independently and iteratively calibrated to represent different components of the watershed system and delineate feedbacks between them. The hydrological and nutrient submodels, which define the hydrological and phosphorus and nitrogen cycles, are the most commonly calibrated submodels used to represent the entire watershed. However, SWAT contains several other submodels (ex. sediment, snow, and crop yield) which are often overlooked even though they represent

sensitive components of the watershed system and can improve model performance. We present a calibration scheme of a SWAT model of the Big Creek Watershed, ON with iteratively calibrated hydrology, snow, crop yield, biomass, sediment and nutrient submodels. The inclusion of sediment and crop yield submodels in our calibration has potential to influence feedbacks between the hydrological, ecological and nutrient components of the SWAT model and result in better characterization of the flow and nutrient loading in the watershed as a whole. Calibration of the snow submodel coupled with a modified rain-on-snow melting process improves characterization of the spring freshet and summer baseflow. Our research suggests that 1) future SWAT studies focused on agricultural management could benefit from including sediment and crop yield submodels in their calibration scheme, and 2) SWAT models of the Great Lakes Basin could benefit from the inclusion of the rain-on-snow process.

**Arthur Zastepa**[1], Judy A Westrick[2], Todd R Miller[3], Anqi Liang[1] and Justin D Chaffin[4], [1]Environment and Climate Change Canada, Burlington, ON, Canada, [2]Wayne State University, Detroit, MI, USA, [3]University of Wisconsin - Milwaukee, Milwaukee, WI, USA, [4]The Ohio State University, Put-In-Bay, OH, USA.
**Beyond total microcystins: Toxic and bioactive metabolites produced by cyanobacteria in Lake Erie's western basin.**

Cyanobacteria produce toxic/bioactive metabolites that can inhibit proteases, carboxypeptidases, or phosphatases involved in metabolic processes relevant to human/ecosystem health. From surface water samples collected in 2017 (n = 44), 2018 (n=100), and 2019 (n = 171), we report concentrations of more than 20 such compounds in western Lake Erie, a large lake of multinational jurisdiction. The most frequently found compounds included microcystins LA and LR as well as anabaenopeptin B and F (>90%). Microcystins RR and YR as well as anabenopeptin A were also detected at relatively high frequency (>80% in 2019). There was strong correlation among arginine-containing variants (RR, YR, HtyR, LR, HilR, WR, D-Asp3-LR, Pearson's r > 0.80) but not with arginine-lacking LY, LW, LF. Anabaenopeptin F also correlated with these same arginine-containing variants (Pearson's r > 0.70). In 2019, only 4% of lake water samples exceeded recreational water guideline for microcystins (10 μg/L) set by Health Canada with maximum concentration ~26 μg/L. Drinking water guideline (1.5 μg/L) was exceeded in 34% of lake water samples but treated water was not tested. Maximum total anabaenopeptins concentration was almost four times higher (almost 100 μg/L) but no guideline values have been derived for this group of metabolites as their impact is considered to be ecological rather than on humans/animals. Results can be used to evaluate risk from cyanobacterial toxins/bioactive metabolites in Lake Erie and aid binational lake management and policy development in the Great Lakes basin.

**Hayden Zavareei**[1], Meagan Froeba[1], Maddie Holm[2], Eli Weaver[1] and Alex Curwin[1], [1]University of Michigan, Ann Arbor, MI, USA, [2]University of Michigan, Dexter, MI, USA. **The Shiawassee Flats: Restoration, Reconnection, and Response.**

Coastal wetlands are an invaluable defense against climate change through the mitigation of flood damage of increasing frequency and magnitude and the offset of emissions via carbon sequestration. The Shiawassee National Wildlife Refuge (SNWR) in Saginaw, MI, USA, provides a clear illustration of how critical the rehabilitation of Great Lake coastal wetlands can be for anthropogenic and ecological communities. The refuge has undergone significant hydrologic restoration over the past decade through reconnecting farm fields to the Shiawassee River. Sitting at the confluence of four principal rivers and influenced by seiches from nearby Lake Huron, the reconnection efforts at SNWR represent the restoration of a historically unique coastal wetland. By collecting data on four parameters, fish, aquatic macroinvertebrates, vegetation, and water quality, across several reconnected wetlands at SNWR, we were able to measure and analyze the impact of restorative actions on the ecological communities. Our data collection revealed how quickly and effectively coastal wetlands can respond after decades of environmental disconnection. The data exemplifies that SNWR is a haven for a wide variety of critical native fish and

macroinvertebrate communities, illustrating the refuge's importance in local ecological resilience and biodiversity.

**Barbara Zeeb**[1], Amelie Litalien[1], William Raymond[1] and Allison Rutter[2], [1]Royal Military College of Canada, Kingston, ON, Canada, [2]Queen's University, Kingston, ON, Canada. **Vascular Plants in the Remediation of Saline Environments: A Dispersal Model using Recretohalophytes.**

Soil and water salinization are growing global concerns, adversely affecting both natural habitats and agricultural lands. A novel method for the remediation of salinized soils utilises recretohalophytes; - plants that secrete salts through specialized glands onto their leaf surfaces. In a process referred to as 'haloconduction', wind blows the excreted salts from the leaves of plants, dispersing and diluting them over great distances. In this study, a model was established to: i) estimate the amount of salt transferred from a given field site, and ii) determine the location and concentrations of deposited salts. Greenhouse and wind tunnel experiments using *Sporobolus michauxianus* were employed to determine excretion and salt emission rates. Based on this data, a theoretical emission profile for *S. michauxianus* was generated at an industrial field site contaminated with highly saline cement kiln dust. Modelling software (AERMOD View) was used to visualize the dispersal of the emitted salts. Simultaneously, a field monitoring program using passive (wet candles) and direct (HiVol) air samplers was undertaken to determine actual airborne chloride concentrations and chloride deposition rates. Based on this model, ~180 kg/year of potassium chloride (KCl) salt could be displaced from the site and deposited over a ~70 $km^2$ region, while maintaining deposition concentrations well below background levels. Similar models are underway for other sites including a salinized roadside and a petroleum extraction site where saline water was produced as a by-product.

**Christina Zeuner**[1], Juan Arce-Rodriguez[2], Jana Levison[2,3] and Marie Larocque[4], [1]Environmental Engineering, University of Guelph, Guelph, ON, Canada, [2]Water Resources Engineering, University of Guelph, Guelph, ON, Canada, [3]Morwick G360 Groundwater Research Institute, Guelph, ON, Canada, [4]Université du Québec à Montréal, Montréal, QC, Canada. **Hydrogeological Transport of Agricultural Nutrients in a Changing Climate: Modelling and Forecasting.**

Determining effective methods for quantifying the future impact of climate is critical for resiliency. The potential for negative socioeconomic impacts on industries and resources, such as agriculture, groundwater quantity and quality, and surface water quality are a concern for Southern Ontario. Impacts from shifting weather patterns, earlier snow melts, and increasing frequency of dry and wet extremes on food production and water quality is complex and not well known. The objective is to quantify future trends in water nitrate concentrations using an integrated SWAT-MODFLOW-RT3D model built using high quality spatiotemporal data and meteorological data from climate change models. Data is collected from the Lower Whitemans Creek subwatershed (in Ontario, Lake Erie Basin) where land use is dominated by cash crops grown on a shallow, overburden sandy aquifer. Highly permeable soils and extreme storm events generate potential for increased nutrient pollution to groundwater. Data from monthly quality monitoring, hourly quantity monitoring, field-scale extreme storm event sampling, and surveys of farmer practices inform the calibration and validation of the model. By modifying modelled land use methods, best management practices can be determined and used to develop more resilient water management policies. Unique data collection methods, experiences, and preliminary results are presented.

**Qian Zhang**[1], Joel D. Blomquist[2], Rosemary M. Fanelli[3], Jennifer L.D. Keisman[2], Douglas L. Moyer[4] and Michael J. Langland[5], [1]University of Maryland Center for Environmental Science / USEPA Chesapeake Bay Program Office, Annapolis, MD, USA, [2]U.S. Geological Survey, Baltimore, MD, USA, [3]U.S. Geological Survey, Raleigh, NC, USA, [4]U.S. Geological Survey, Richmond, VA, USA, [5]U.S. Geological Survey, New

Cumberland, PA, USA. **Progress in reducing nutrient loads to Chesapeake Bay: A synthesis of three decades of monitoring data and research.**

For over three decades, Chesapeake Bay (USA) has been the focal point of a coordinated restoration strategy implemented through a partnership of governmental and nongovernmental entities, which has been a classical model for coastal restoration worldwide. This synthesis aims to provide resource managers with a clearer perspective of the magnitude of changes in water quality in the Bay watershed, including the River Input Monitoring (RIM) watershed and the unmonitored below-RIM watershed. The flow-normalized nitrogen (N) load from the RIM watershed has declined in the period of 1985-2017, but phosphorus (P) and sediment loads have lacked progress. Reductions of N are largely driven by reductions of point sources and atmospheric deposition. Future reductions will require progress in managing agricultural nonpoint sources. The below-RIM watershed, which comprises a disproportionately high fraction of inputs to the Bay, showed long-term declines in major sources, including point sources (N and P), atmospheric deposition (N), manure (N and P) and fertilizer (P). To date, the cleanup efforts have achieved some progress toward reducing watershed loads, which have resulted in improving water quality in the estuary. However, further reductions are critical to achieve the Total Maximum Daily Load goals, and emerging challenges due to Conowingo Reservoir, legacy nutrients, climate change, and population growth should be considered. Continued monitoring, modeling, and assessment are critically important for informing the restoration of this complex ecosystem.

**Bowen Zhou**[1], Mahyar Shafii[2], Chris T Parsons[3], Elodie Passeport[4], Fereidoun Rezanezhad[1], Ariel Lisogorsky[1] and Philippe Van Cappellen[2], [1]University of Waterloo, Waterloo, ON, Canada, [2]Ecohydrology Research Group, University of Waterloo, Waterloo, ON, Canada, [3]Environment and Climate Change Canada, Burlington, ON, Canada, [4]Department of Civil & Mineral Engineering University of Toronto, Toronto, ON, Canada. **Analysis of phosphorus accumulation in an urban bioretention cell using reactive-transport modelling.**

Bioretention cells (Bio-C) have emerged as a popular low impact development (LID) option to attenuate both flow discharge and reduce nutrient export from urban areas. We present a novel numerical reactive transport model that incorporates a detailed representation of the phosphorus (P) biogeochemical reaction network. The model was applied to an extensive P data set collected for a Bio-C system in Mississauga in the Greater Toronto Area, to identify the possible P retention processes and their contributions to the P accumulation trajectory within the Bio-C over eight years of operation. Model results were validated against time series of flow discharge, water chemistry, as well as depth profiles of total P (TP) in the filter media measured between 2012 and 2019, and the depth distributions of P pools obtained with sequential chemical extractions in 2019. Model results indicated that exfiltration was the dominant pathway decreasing the surface runoff discharged from the Bio-C (63% reduction) while retention within the Bio-C filter media was the major process reducing the surface TP load (57% reduction). Moreover, close to 90% of the retained P accumulated under stable forms, hence diminishing the risk of long-term P remobilization from the Bio-C.

**Xing Zhou**[1], Pengfei Xue[1], Mark D. Rowe[2], Peter J Alsip[3], David B. Bunnell[4], Tomas O Hook[5], Edward Rutherford[2], Paris D Collingsworth[5], Spencer T Gardner[6] and Anna Li Holey[1], [1]Michigan Technological University, Houghton, MI, USA, [2]NOAA GLERL, Ann Arbor, MI, USA, [3]Cooperative Institute for Great Lakes Research, University of Michigan, Ann Arbor, MI, USA, [4]USGS Great Lakes Science Center, Ann Arbor, MI, USA, [5]Illinois-Indiana Sea Grant, West Lafayette, IN, USA, [6]Purdue University, West Lafayette, IN, USA. **Impact of Climate Change Scenarios on Phytoplankton in Lake Michigan: A Biophysical Modeling Study.**

Regional warming can profoundly influence Laurentian Great Lakes (LGL) ecosystems. Climatic changes can alter phytoplankton structure and seasonal dynamics by modifying environmental factors such as temperature, water column mixing, and light availability. We conducted historical simulations (2005–

2014) and future projections of climate change effects on Lake Michigan for the mid-21st century (2041–2049) and the late 21st century (2091–2099) using the Representative Concentration Pathway (RCP) 8.5 scenario. Simulations were performed using an integrated modeling approach consisting of a two-way coupled 3D lake-ice–climate modeling system (GLARM), a hydrodynamic model (FVCOM), and a nutrient-phytoplankton-zooplankton-detritus (NPZD) model with a fifth compartment added to represent the invasive quagga mussel *(Dreissena rostriformis bugensis*), a benthic filter feeder of phytoplankton. Based on simulation results, we provided a discussion of how climate change scenarios modify environmental factors to influence the future spatial and temporal patterns of phytoplankton abundance. In addition, we evaluated model sensitivity to scenarios of varying mussel biomass density, tributary phosphorus loading, and basin runoff. These factors are regarded as potentially alterable factors in the future due to climate change or management actions.

**Longhuan Zhu**[1], Pengfei Xue[1], Guy A. Meadows[1], Chin Wu[2] and Cary D. Troy[3], [1]Michigan Technological University, Houghton, MI, USA, [2]University of Wisconsin-Madison, Madison, WI, USA, [3]Purdue University-West Lafayette, West Lafayette, IN, USA. **Trends and variations of coastal erosion in Lake Michigan.**

Coastal erosion has been an increasingly prominent concern in Lake Michigan, especially the rapidly fluctuating water levels and increasingly intensive storms during the last several decades. This study aims to examine the spatial variations of coastal erosion from local, regional, and whole (LRW) lake scales. Specifically, a coupled wave-current-sediment model is employed to reveal the 30-year (1991-2020) spatiotemporal characteristics of the basin-wide nearshore sediment budget (NSB), as proxies for coastal erosion, in Lake Michigan. We further investigate the impacts of coastal structures on NSB under extreme events near South Haven, MI as an example of a mid-sized navigational jetty. Temporal trends of NSB from LRW lake scales are depicted, which may be caused by either wave climate, water level, or both. Overall, the trends and variations of coastal erosion and causes provide the understanding and guidance of coastal management and protection decision for the community.

**Yuanyan Zi**[1,2], Xuexiu Chang[3], Hugh J. MacIsaac[4] and Justin R. Barker[2], [1]Kunming University, Kunming, China, [2]University of Windsor, Windsor, Canada, [3]College of Agriculture and Life Sciences, Kunming University, Kunming, China, [4]Yunnan University, Kunming, China. **Identification of potential mechanisms of action and toxins for immunotoxicity of cyanobacteria exudate mixtures.**

Cyanobacterial blooms pose a threat to aquatic species. Immune damage caused by cyanobacterial secondary metabolites is one of the important reasons. *Microcystic aeruginosa* is the dominant global species of freshwater cyanobacterial blooms, its exudates (MaE) can cause immune damage, but specific immunotoxins in MaE are unknown. It is critical to explore mechanisms and chemicals associated with immunotoxicity of MaE. We screened 111 immunotoxicity assays from the ToxCast database to identify MaE's targets of action using machine learning. We then built a potential Adverse Outcome Pathway to identify immunotoxicity mechanisms of action based on target relationships. Finally, we selected two potential immunotoxins and matched them with molecular initiation events using molecular docking. We found MaE could change the immune response due to 29 targets being inhibited and 9 targets being activated. MaE suppressed the immune system mainly by impairing the tumor necrosis factor signaling pathway or by inhibiting the major histocompatibility complex class II DR alpha. We identified two immunotoxic MaE compounds – ziziphin and 2-acetyl-1-alkyl-sn-glycero-3-phosphocholine. Our study enhances understanding of immunotoxicity mechanisms and identifies immunotoxins in MaE, which may help identify priority compounds for future management.

**Carly Ziegler**, Edgewood College and Campus School, Madison, WI, USA. **Inciting stewardship action in middle school students through long-term limnology data collection.**

Stewardship is a rapidly identifying goal amongst primary and secondary science teachers. But stewardship is much more than embracing the natural ecosystems of our planet. Instead, it requires an understanding of as well as a sense of responsibility towards these ecosystems. We explore how Great Lakes Principles have been applied to a local chain of lakes in Madison, Wisconsin in order to teach stewardship by guiding students to become experts throughout a long term research project that explores the state of the lakes from a biotic and abiotic perspective. In this middle school exploration, students meet NGSS in life, physical, and earth sciences as they engage in science and engineering principles that require them to plan, carry out, and analyze data from a multi year study. Students use this information to incite action through a citizen action component to enact change in their own communities. While this presentation focuses on middle school science standards, it could easily be applied to secondary and post secondary education.

**Peter Zuzek**[1], Seth Logan[2], Danker Kolijn[3], **Isaac Noyes**[4], Ryan Stainton[4], Danielle MacCorkindale[4] and Mike Passey[4], [1]Zuzek Inc., Hamilton, ON, Canada, [2]SJL Engineering, Ottawa, ON, Canada, [3]DHI Group, Vancouver, BC, Canada, [4]Ministry of Natural Resources and Forestry, Peterborough, ON, Canada. **Climate Change Impacts on Flooding Hazards for the Great Lakes.**

Overview of the results from an update of the joint probability analysis of 100-year flood levels on all 23 water level gauges on the Canadian side of the Great Lakes and Lake St. Clair, which includes projected storm surge and lake level projections under climate change. Additionally, the 100-year flood levels between gauge locations have been calculated for Lake Huron and Georgian Bay using numerical modelling techniques and projected climate change impacts. This methodology has been documented to serve as a template for full scale numerical modelling updates to the other Great Lakes flood levels. Analysis of monthly data series allows the development of seasonal/monthly maxima values, as opposed to annual maxima, for greater sub-annual resolution on expected climate change impacts.