ABSTRACTS

International Association for Great Lakes Research

67th Annual Conference on Great Lakes Research | May 20–24, 2024

67th Annual
Conference on Great Lakes Research

Convened by the
International Association for Great Lakes Research

May 20–24, 2024

Hosted by the
University of Windsor

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International Association for Great Lakes Research
4840 South State Road
Ann Arbor, Michigan 48108
iaglr.org

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ABSTRACTS

An alphabetical listing of abstracts presented at the 67th Annual Conference on Great Lakes Research, organized by first presenter's last name. Presenters are underlined.

A

Hazem Abdelhady and Cary Troy, Purdue University. **A Deep Learning Framework for Hindcasting Lake Michigan Ice Cover and Wave Height.**

Understanding and predicting hydrodynamic parameters such as ice cover and wave heights are of paramount importance for weather prediction, coastal resilience, water resource management, aquatic ecosystem assessment, and transportation. In particular, from a coastal resilience perspective, the accurate prediction of wave heights and ice cover is essential for effective coastal management and erosion mitigation strategies. In this presentation, I will introduce a new deep learning framework based on the Convolution Long Short-Term Memory (ConvLSTM) and Convolution Neural Network (CNN) to model and extend the current records of wave heights and ice cover datasets. This novel approach has been applied to Lake Michigan, incorporating meteorological data, water depth, and shoreline proximity as input features. The Wave Information System model (WIS) and Ice Cover charts served as the training, validation, and testing datasets for the proposed deep learning models. To account for the influence of ice on wave generation in Lake Michigan, the ice model was employed to add 23 years of ice cover data to the existing ice charts, increasing it by almost 50%. The combined ice and waves model has expanded the existing wave height time series by an additional 30 years, representing a remarkable 70% increase. This extension provides valuable insights into the long-term wave climatology and ice dynamics helping in the design of sustainable and resilient coastal structures.

Josef Ackerman[1], Gabriel Smith[1], Leon Boegman[2] and Rao Yerubandi[3], [1]University of Guelph, [2]Queen's University, [3]Environment and Climate Change Canada. **Spatial and temporal dynamics of near-bottom dissolved oxygen in the central basin of Lake Erie.**

We examined the spatial and temporal patterns of hypoxia in the central basin of Lake Erie along a ~26 km west-east transect (depth: 11.4 m in the west to 20 m in the east). Water column properties were monitored using moored (DO, temperature, turbidity, Chlorophyll *a*) and profiling instruments in cruises in 2008 and 2009. Hypoxia was examined using a biologically relevant value of 40% DO saturation (i.e., DO ~ 4 mg/L) and 25% DO sat (i.e., DO ~ 2 mg/L) used by agencies. We observed interannual differences in the spatial and temporal DO patterns likely due to different water levels and stronger winds, which resulted in a smaller hypolimnion and lower thermocline depth in 2009. Near-bottom hypoxia occurred during the end of June in 2008 in the east and extended westward by the end of July for 40% saturation, but occurred later using 25% saturation (early July to mid-August). The onset of hypoxia (40% sat) occurred earlier in the west in 2009 but the timing was similar to 2008 using 25% sat. Both the frequency and duration of hypoxic events (>

min scale) were higher and longer in 2008, likely due to suspension of bottom sediment by synoptic-scale storms, which coincided with low oxygen events. Understanding the spatial and temporal patterns of hypoxia provides insight into their effects on habitat quality as well as biogeochemical processes in benthic environments in Lake Erie.

Amanda Ackiss[1], J. Vinnie Siegel[1], Katie Anweiler[1], Ryan Lauzon[2], Ann Ropp[1] and Joseph Schmitt[3], [1]USGS Great Lakes Science Center, [2]Chippewas of Nawash Unceded First Nation, [3]USGS Great Lakes Science Center, Lake Erie Biological Station. **Ghosts and relics of Lake Erie: a genomic comparison of historic and contemporary *C. artedi.***

Historically Lake Erie supported the largest cisco (*Coregonus artedi*) fishery in the Great Lakes, but by the 1960s this massive resource had collapsed. Today, Lake Erie remains the only Great Lake from which cisco were extirpated. There is growing interest in re-establishing cisco in Lake Erie, and genomic tools can provide valuable information about historical and contemporary diversity. Here, we extracted DNA from 475 scale samples collected between 1927-1943 from four regions across Lake Erie in both US and Canadian waters. We successfully genotyped >180 of these samples using a GT-seq panel and compared them to contemporary cisco from Lake Ontario and contemporary and historical ciscoes from Lake Huron. Our results indicate Lake Erie was home to a unique stock of cisco that was substantially differentiated from historical and contemporary stocks in other Great Lakes. We also found evidence of migrants from Lake Huron as well as the presence of a handful of samples that genotyped similarly to historical *C. alpenae* from Lake Huron. Finally, we used the newly genotyped historical samples to explore the origin of a contemporary population of inland cisco in Crystal Lake, Pennsylvania which are hypothesized to have descended from Lake Erie cisco larvae stocked in this region in 1929. We found considerable genetic evidence to support this theory, indicating the likely presence of a rare, remnant population of the once abundant Lake Erie cisco.

Kevin Adeli[1], Trevor Pitcher[2], Jacques Rinchard[3] and Bryan Neff[1], [1]Department of Biology, University of Western Ontario, [2]Great Lakes Institute for Environmental Research, University of Windsor, [3]Department of Environmental Science and Ecology, State University of New York Brockport. **Thiamine concentration and heart morphology of alternative reproductive life histories in Chinook salmon *(Oncorhynchus tshawytscha).***

Chinook salmon (*Oncorhynchus tshawytscha*) are a focal point of stocking initiatives in the Laurentian Great Lakes largely due to their efficacy in controlling invasive populations of alewife (*Alosa pseudoharengus*). Male Chinook salmon have two alternative reproductive life histories that differ in their dietary niche. In Lake Ontario, the larger hooknose males occupy a more pelagic trophic niche than precocial jack males, indicating that hooknose males likely consume more alewife. A challenge for Chinook salmon conservation in Lake Ontario is thiamine (vitamin B_1) deficiency, which can arise from the consumption of alewife. Thiamine deficiency has a plethora of negative effects including recruitment failure and cardiovascular constraints. However, no research to date has investigated how thiamine deficiency and its effects on the cardiovascular system may differ across alternative reproductive life histories of Chinook salmon. Here, we sampled spawning hooknose, jack, and female Chinook salmon from the Credit River (Mississauga, Ontario) and determined muscle, liver, heart, and egg thiamine concentrations for each life history. We then related these concentrations to various metrics of heart morphology and health which differed significantly between reproductive life histories.

Jeremiah Adesanya, Megan Lynagh and Chris Ward, Bowling Green State University. **Exploring mutualistic interactions between aquatic bacteria and *Scenedesmus*.**

Mutualistic interactions between eukaryotic microalgae and heterotrophic bacteria are consequential to algal ecophysiology, including growth and metabolism. *Scenedesmus* spp. are green algae ubiquitous in eutrophic freshwater bodies including Lake Erie. We aim to identify several mutualistic microbes, with a particular interest in bacteria belonging to *Rhizobiales* (known plant growth-promoting bacteria) and dissect their mechanisms of interaction with *Scenedesmus*. To date, we have isolated more than forty *Rhizobiales* strains from Lake Erie, characterized through morphological and biochemical tests. We are currently conducting experiments co-culturing *Scenedesmus* strains (*S. obliquus, S. dimorphus*) with single bacterial strains and screening them for effects on algal cell growth and lipid production. Bacteria that cause significant algal changes will be further characterized through biochemical assays (e.g. production of auxins and essential vitamins, as well as nitrogen fixation potential) and whole genome sequencing. By identifying mutualistic microbial interactions of common freshwater microalgae, we may gain a greater understanding of the important roles that algal microbiomes have in modulating lake primary production and food web dynamics.

Anjana Adhikari[1], Harriet Okeyo[2] and Mercy Chepkirui[2], [1]University of Wisconsin- Milwaukee, [2]Kenya Marine and Fisheries Research Institute. **Integrating Drying Effects with Mass-Spectrometric Analysis: Microcystin Levels in Fish from Lake Victoria.**

Ninety percent of the fishermen who depend on Lake Victoria (LV) have been periodically impacted by Harmful Algal Blooms (HABs). We hypothesize that microcystin (MC) produced during HABs binds to protein in fish and can accumulate in fish tissue over time. The accumulated concentration of MC in the fish tissue subsequently impacts socioeconomic health. Protein-bound MC in fish might be due to frequent HABs, affecting the fish population in LV. The comparative mass spectrometric analysis of the total concentration of augmented MC in the traditionally dried Dagga, Nile Perch, freshwater shrimp, and Tilapia from LV to the concentration of MC present in the freshly caught fish tissue will provide insight into whether the cyanotoxin decreases or increases upon drying. Additionally, measuring MC in the water from the area where the fish was caught provides a perspective on whether the concentration of MC accumulated in the fish and the MC present in the water have any relationship. The MC analysis will provide evidence on whether the traditional method of sun drying the fish is of essence to human and socioeconomic health. This research study involves a multinational-interdisciplinary approach with early-career Kenyan researchers assisting with sample processing in Lake Victoria and the samples being analyzed by the presenter in the United States.

Najiha Afnan[1], Adam Cornwell[1], Kamil Zaniewski[1], Robert Stewart[1] and Pradeep Goel[2], [1]Lakehead University, [2]Ontario Ministry of the Environment. **Impacts of Projected Future Temperature Rise on the Hydrology of Neebing River, Ontario.**

The projected future temperature rise is likely to change the Neebing River's hydrology over the following decades. The changing hydrological patterns are expected to cause increased hydrological extremes in the city of Thunder Bay, Ontario. To safeguard this city from future climatic extremes, it is necessary to understand Neebing River's hydrological response to the anticipated future temperature rise and consider efficient prevention and long-term adaptation techniques. This study investigates the potential impacts of projected future temperature rise on the hydrology of the Neebing River watershed and identifies potential mitigation and adaptation strategies. The Soil and Water Assessment Tool (SWAT) has been used to simulate the future

streamflow for the period of 2041-2050 (near future) and 2091-2100 (distant future). The future air temperature and precipitation projections have been derived from three Global Climate Models (CanESM5, GFDL-ESM4, and HadGEM3-GC31) under medium (SSP2-4.5), and high (SSP5-8.5) emission scenarios. The SWAT model results reveal that compared to the baseline period of 2008-2017, the streamflow will increase significantly during those two ten-year periods. The findings of this study are expected to guide policy decisions intended to minimize damages from the unavoidable impacts of the projected future temperature rise. This study will also contribute to our understanding of the climate response of rivers in the Lake Superior basin and Northern Ontario in general.

Laya Ahmadi and Christopher Wellen, Toronto Metropolitan University. **Understanding fertilizer choice using detailed land management surveys and multinomial logistic regression.**

Eutrophication is a continuing water quality hindrance in the Laurentian Great Lakes, and is driven largely by excess phosphorus inputs. There is significant interest in reducing phosphorus losses to downstream ecosystems from multiple sources, including agricultural nonpoint sources. Recent research has highlighted the importance of subsurface placement of fertilizers in reducing losses to downstream ecosystems. There is little research in Canada that examines the factors that influence farmers' decisions to apply fertilizer on or below the surface of their fields. Existing research in Canada and the US on beneficial management practices tends to rely on self-reported probabilities of adoption, as little data on actual adoption at the individual level is available. This leads to some level of uncertainty as to the scope for uptake of beneficial management practices such as sub-surface fertilizer application. This research applies multinomial logistic regression to the Agri-Model land management survey administered to 160 farmers that manage 1261 farm fields in 11 watersheds in Southwestern Ontario. Logistic regression allows us to quantify the factors most influential for determining the likelihood that a particular fertilizer application is applied below the soil surface. The results of this investigation will help guide regional modelling efforts, while also helping guide land management.

Claire Ajambo[1,2], [1]Makerere University, [2]African Women in Science. **Women Economic Empowerment for Bugiri District Uganda through Cage Fish Farming.**

At the shores of Lake Victoria, the largest freshwater body in Africa shared by Uganda, Kenya, and Tanzania lies a district called Bugiri in Eastern Uganda. According to the economic study by the Uganda Bureau of Statistics in 2016, Bugiri was ranked among the districts with highest levels of poverty and food insecurity. More so, the district had a high number of disadvantaged women who were providers of basic needs to their families. Fish farming is among other businesses that was identified to be a source of income, food and nutrition to the women in the district. With funding from UN Women and Stanbic bank of South Africa, Government of Sweden, Msingi East Africa, a project on farming Nile tilapia in cages at Wakawaka landing site was proposed and implemented. The project activities included needs assessment study to establish baseline information, training of women on basic fish farming techniques, procurement of inputs, construction and installation of 28 cage frames on water, fish fry stocking, feeding, harvesting, post-harvest handling, and value addition, among others. 1,400 women who were organized in a cooperative were capacitated in a company, Women Economic Empowerment Bugiri (WEEB) to operate this fish farming business on their own, keep records, and track their profits. In conclusion, this has empowered the women, reduced poverty, ensured food and nutrition in Bugiri district, Uganda, and the region at large.

Zahra Akbarzadeh[1], Serghei Bocaniov[1], Helen Powley[2], Kevin Lamb[3] and Philippe Van Cappellen[1], [1]Department of Earth and Environmental Sciences, University of Waterloo, [2]Plymouth Marine Laboratory, [3]Department of Applied Mathematics, University of Waterloo. **Phosphorus dynamics in Lake Erie's littoral zone: Insights from a regionalized mass balance model.**

Eutrophication is a major problem in the nearshore areas of large lakes. The nearshore areas are the primary recipients of nutrient loading from their watersheds. Furthermore, they act as biogeochemical reactors that can strongly affect the in-lake fate and transport of the nutrient elements delivered to the lake. Here, we focus on phosphorus (P) dynamics in the shallow littoral zone of Lake Erie. We developed a regionalized mass balance model for Lake Erie in which the lake is divided into the shallow western basin and Sandusky sub-basin, plus five nearshore and two offshore compartments. The model represents both the dissolved (DP) and particulate (PP) fractions of total P (TP) in the water column, plus TP in the bottom sediments. The mean annual P loadings for the period 2003-2016 from land and atmosphere, along with the mean annual water fluxes between the different lake compartments were imposed. Special attention was given to estimating the littoral-offshore water exchange fluxes because little is known about how these affect the whole P cycling. Overall, our results highlight the role of littoral zone processes in shaping the lake's phosphorus budget. Additionally, we carried out model simulations to analyze the effect of changes in water circulation on the littoral-offshore P exchanges. Such changes may help explain why, in contrast to the shallow littoral areas, deeper offshore areas of Lake Erie are experiencing declining primary productivity.

Razegheh Akhbarizadeh[1], Yan Jin Xu[1], Anlun Guo[1], Mirima Diamond[1, 2] and Paul Helm[2, 3], [1]Department of Earth Sciences, University of Toronto, Toronto, [2]School of the Environment, University of Toronto, Toronto, [3]Environmental Monitoring and Reporting Branch, Ontario Ministry of the Environment, Conservation and Parks, Toronto. **Microplastics load into Lake Ontario through the Etobicoke creek watershed.**

Urban streams play a significant role in transporting land-derived microplastics (MPs) to the Great Lakes. Our research contributes to understanding the dynamics of their emissions in streams, and consequently, the analysis of loading during rainfall/runoff events versus dry events. Throughout a year of sampling, we assessed the temporal variability of MPs (> 250 μm), comparing their levels and loads under low-flow conditions with those observed during rain events. We used a tested, "safe" digestion extraction method for isolating aged MPs from stream water. The median concentrations of MPs during rain events and dry events were 1.3 items/L (n=23) and 0.11 items/L (n=13), respectively; and the corresponding median load for rain and dry events were 2.1 x 10^3 and 0.26 x 10^3 items/second, respectively, based on the mean discharge values on the sampling date. Stream flow rate showed a strong, significant positive correlation with fragments and rubber particles (p< 0.05, r>0.7), while no significant relationships were found between commercial/crescent shape fragments, spherical microbeads and plastic pellets (p>0.05) with velocity. These substantial loads of MPs to Lake Ontario through the urban stream may have environmental implications for the freshwater ecosystem.

Odai Al Balasmeh, Akunne Okoli, Alex Neumann and George Arhonditsis, University of Toronto. **Analysis of geospatial data to support ensemble modeling in the Canadian side of Lake Erie drainage basin.**

In line with plans for nutrient loading reduction in the Canadian side of Lake Erie basin, detailed analysis has been conducted to evaluate the quality and quantity of existing geospatial data to support development of ensemble of watershed models. We estimated available soil information

based on Soil Landscapes of Canada and Detailed Soil Surveys to support watershed modeling and identification of potential nutrient hot spots. Next, we estimated long-term changes in land use/land cover based on remote sensing products. Similarly, we evaluated census data on intensity of agricultural activity in terms of farming practices, crop yields, livestock numbers, manure production, potential inputs of mineral fertilizers, and estimates on nutrient balance in soil manifested as legacy nutrients. The evaluation considered the spatial resolution, reported accuracy in data, and potential effect on development of nutrient loading reduction plans.

Elizabeth E. Alexson, Euan D. Reavie, Holly A. Wellard Kelly and Leah R. Schleppenbach, University of Minnesota Duluth, Natural Resources Research Institute. **Diversity and abundance of protozoa in the Laurentian Great Lakes.**

Though there are relatively few studies, literature suggests heterotrophic protists play an important role in Laurentian Great Lakes food webs. To date the analysis of these organisms has been largely excluded from the USEPA's Great Lakes Biology Monitoring Program, which supports characterization of the base of Great Lakes pelagic food webs. As a part of this program we analyze phytoplankton communities, and to better understand the role of protozoans we began incorporating their identification and enumeration into microscopic algal analysis in 2022. We aim to develop the Great Lakes faunal library for protozoans and examine how these communities change spatially (across all five lakes) and temporally (seasonally and annually). Preliminary data reveal a large diversity of Ciliophora (Oligotrichea, Gymnostomatea, Prostomatea, Oligohymenophorea, and Kinetofragminophora), Choanoflagellates, and Sarcodina. We will present our inaugural year's data and demonstrate the importance of the continued monitoring of these abundant organisms.

Tait Algayer[1], Subba Rao Chaganti[1], Lucas Vanderbuilt[1], Heather Truong[2], Madeline Tomczak[1], Mark Rowe[3], Eliza Lugten[3], Paul Glyshaw[3], Katrina Lewandowski[4] and Edward Rutherford[3], [1]Cooperative Institute for Great Lakes Research, [2]Eckerd College, [3]Great Lakes Environmental Research Laboratories, [4]Wayne State University. **Tracking larval fish dispersal and relative abundance in Lake Michigan using environmental DNA.**

Alewife *Alosa pseudoharengus* and yellow perch *Perca flavescens* are ecologically and economically important Great Lakes fishes. Adults of both species spawn in nearshore environments, making their larvae highly susceptible to advection via currents and lake circulation patterns. Recruitment success of these species can be largely influenced by advection of larvae into or away from productive nearshore habitats. Traditional methods for monitoring larval fish dispersal in the Great Lakes are labor and cost intensive, and more recently developed numerical hydrodynamic models often lack predictive accuracy. eDNA sampling is a widespread, reliable method used for aquatic species monitoring, but typically has only been used for detecting species presence or absence. Our results from laboratory trials with larval yellow perch suggest that eDNA sampling also can be used to estimate relative abundance of target species within 24 hours of site visitation. To determine whether eDNA could be applied to estimate larval fish relative abundance, we deployed drifters in Lake Michigan and used output from a hydrodynamic model to track water movements and identify eDNA sample sites for detecting fish larvae. Results indicated that cycle threshold values from real-time PCR reflected the relative abundance of larvae in ichthyoplankton tows from a given site. Our findings illustrate the potential for molecular genetic methods to monitor relative abundance of fish species in the Great Lakes.

Peter Alsip[1], Mark Rowe[2], Alex Kain[1], Dale Robertson[3], James Kessler[2] and Dan Titze[2], [1]University of Michigan, Cooperative Institute for Great Lakes Research, [2]NOAA Great Lakes Environmental Research Laboratory, [3]U.S. Geological Survey, Upper Midwest Water Science Center. **An Experimental Biophysical Forecast System to Support Lake Huron CSMI 2022.**

For the 2022 Cooperative Science and Monitoring Initiative (CSMI) field year on Lake Huron, NOAA GLERL and CIGLR developed a biophysical forecast model to support field research. This effort supports science priorities related to understanding the contributions of tributary nutrient inputs to nearshore water quality and productivity hotspots. This model builds on NOAA's Lake Michigan-Huron Operational Forecast System hydrodynamic model and simulates a phosphorus (P) limited lower food web that incorporates estimated tributary P concentrations and discharge from 124 rivers, 84 of which flow into Lake Huron. Dissolved organic carbon (DOC) was included as a tracer from river inputs. We evaluated real-time model performance primarily by comparison to satellite-derived chlorophyll and DOC concentrations. The model simulated spatial and temporal patterns in chlorophyll and DOC, such as the transport of productive water from Saginaw Bay along Michigan's coast to the St. Clair River outflow and elevated DOC associated with tributary inputs in Georgian Bay and the North Channel. We will present examples of the biophysical forecasts, comparisons to satellite data, and web products designed to support field researchers. We will demonstrate how real-time biophysical forecasts can help field researchers locate transient features in dynamic nearshore areas, provide context to observations, and inform planning of future surveys.

Eric Anderson, Colorado School of Mines. **Filling in the Gaps: The Underrated, Misunderstood, and Unfolding Story of Meteotsunamis.**

Forecast systems in the Great Lakes are designed to protect life and property, and overall help bolster community resilience to extreme events. Measuring and predicting currents, water temperatures, water levels, ice, and waves have been key physical parameters of interest to public and scientific communities alike. However, for most of the observed record, in which monitoring platforms and data archives have existed, and even up to the present, there has been a gap in our ability to detect meteotsunami waves. Meteotsunamis are long waves with periods that fall between wind waves and seiche. While meteotsunamis have likely impacted Great Lakes shores since their formation, over the last century, these events were largely mis-characterized as seiche, tidal, or rogue waves. And yet, these events that led to fatalities, injury, capsize ships, flooding, and damage continue to elude forecast models and many observing systems. Not until an event in Lake Erie in 2012 were meteotsunamis identified in the Great Lakes. However, since then significant progress has been made in understanding their generation, frequency, and impacts. Recently, work has shown that meteotsunamis are more than a rare hazard, and in fact, can occur regularly and play important roles in coastal sediment resuspension and wetland functioning. This talk summarizes GLERL's role in the history and state of knowledge on meteotsunamis and will provide insight into future directions.

Jacob Anderson[1], Mary Austerman[1], Matthew Hoffman[2], Nathan Eddingsaas[2], Tom Snyder[3], Shawn Gee[4], Kaeti Stoss[2], Autumn Potts[2] and Christy Tyler[2], [1]New York Sea Grant, [2]Rochester Institute of Technology, [3]Seneca Park Zoo, [4]SRGMF. **Mitigation of Stormwater-Derived Debris: A Community-Based Approach.**

Stormwater is one of the dominant sources of debris to aquatic systems. Preliminary data shows that debris input and transport is temporally and spatially variable, suggesting that a hyper-local approach to input mitigation is needed. The intent of this project is to build a community

network engaged in debris prevention and remediation in the City of Rochester and the watershed of the Rochester Embayment of Lake Ontario. Building on existing programming and collaborations among individual groups, we are developing a sustainable and transferable program to tackle the issue of stormwater-derived debris in the City of Rochester. Our partnership consists of local municipal agencies, premier non-profit conservation and education organizations, local educational consultants, and higher education. Ten "Littatraps," a debris interception technology that consists of a mesh basket installed in stormwater catch basins, have been installed adjacent to recreational and educational facilities in environmental justice areas of the City. Targeted programming implemented at each site aims to increase engagement, develop environmental literacy and data skills, improve environmental stewardship, and build marketing and advocacy skills of city youth. The ultimate goal is to reduce stormwater-derived anthropogenic debris in Lake Ontario, foster a sense of community responsibility, and create pride in the health of our local waterways.

Joshua Anderson[1], Joseph Zhang[2], David Cannon[3], Dan Titze[4], Dmitry Beletsky[3], Jesse Feyen[4] and Chin Wu[1], [1]University of Wisconsin Madison, [2]Virginia Institute of Marine Science, [3]Cooperative Institute for Great Lakes Research, [4]Great Lakes Environmental Research Laboratory. **Temporal and Spatial Characteristics of Internal Seiches in Lake Champlain.**

Lake Champlain is the 6th largest body of freshwater in the U.S. located on the border of New York and Vermont. The lake is long and narrow, extending roughly 170 km from north to south and 20 km at its widest point. This basin shape combined with a maximum depth of 120 m and summertime stratification creates conditions for an internal seiche with a fundamental period near 4 days. Since weather and winds often change near this period, the wind stress forcing resonates with the internal seiche motion causing large excursions of the thermocline up to 40 m. During these large events, currents near 0.5 m/s have been observed in the epilimnion and hypolimnion with implications on nutrient transport and sediment resuspension. Due to the sparse availability of observations, the spatial and temporal variation of the internal seiche remains largely unknown. In this talk, a baroclinic application of the hydrodynamic model SCHISM is applied to examine the temporal and spatial characteristics of the internal seiche in Lake Champlain. Model results are assessed with recent and historical observations to reveal SCHISM's exceptional ability to capture internal wave dynamics. Results are further examined to reveal the spatial structure of internal waves as they evolve through time and the role of Earth's rotation on this process. Finally, the existence of a 2nd and 3rd mode of oscillation of the internal seiche is examined.

Morgan Anderson, Lisa Peters and Pauline Gerrard, IISD-ELA. **Communicating the complex scientific workings of environmental DNA (eDNA) to different audiences.**

Communicating complex environmental research to the public is increasingly difficult. However, prioritizing effective science communication is essential to ensure the benefits of research extend to all corners of our global community and attract youth, particularly young women, to science careers. The IISD-Experimental Lakes Area Education and Relations group strive to find unique and engaging ways to connect our research with the public. Targeted programs for high school students, such as Experimental Lakes area Student Experience (ELSE) summer field course, educational day programs with local public schools and outreach events with the local communities and citizen science groups, freshwater science can be made accessible. New and emerging concepts and techniques such as environmental DNA (eDNA) are covered in our Monitoring Environmental DNA & Learning Ecology with Youth (MEDLEY) program which targets grade 11-12 students. We have also developed eDNA programming for primary school age students. Research shows that increasing exposure to scientific concepts through age-appropriate science programming in

elementary schools, and lab tours with hands on activities for middle to secondary school students are excellent ways to spark interest in science careers. Female role models promoting science and mentorship programs attract and retain young women in STEM careers. The importance of science communication and education lies not only in its ability to convey scientific knowledge, but also in its capacity to break down barriers, fostering a more inclusive and informed society.

Ovie Augustine and **Samuel Anwuzia**, University of Benin. **The preliminary assessment of the deteriorating state of a dam in north-western Nigeria using Macroinvertebrates assemblage and environmental factors.**

We examined invertebrate community assemblages responses to some physicochemical parameters in Kalgwai Dam; north-western Nigeria monthly in three stations for six months between January and June 2022. Physico-chemical parameters and invertebrates were collected monthly on each sampling occasion. Dissolved Oxygen (DO) concentrations were lowest in Station 1 (3.79 ± 0.53 mg−1), and phosphate, pH, and turbidity were highest in Station 3. Tukey's Honestly Significant Difference (HSD) test showed that the mean values of DO, TDS, EC, and turbidity were significantly different ($p < .05$) among the three sampled stations. A total of 379 phytoplankton individuals belonging to 8 divisions and 60 taxa were identified in the study, and the Baetidae family was the most predominant family of invertebrates in the dam. A higher abundance of invertebrates was recorded in the dry season than in the wet season. Analysis of variance (ANOVA) calculated for biological indices showed no significant difference among the months sampled ($p > .05$). The Canonical Correspondence Analysis (CCA) model revealed a relationship between invertebrate communities and measured physicochemical variables. Species such as Caenis spp, Chironmus sp and Cheumatopsyche sp. indicated a strong positive correlation with increasing physico-chemical parameters such as nutrients and BOD5 at Station 1. These species were considered indicators of prevailing environmental conditions in the study area. Cluster analysis (Jaccard similarity) showed species of invertebrates to be clustered by season rather than by stations.

Dana Arends and Jason Olsthoorn, Civil Engineering, Queen's University. **Modelling the bathymetric influence on ice melt for an idealized ice-covered lake.**

While many studies have considered the effect of climate change on the increasing temporal variability of ice cover, the spatial variability of lake ice cover thickness is not discussed as often. It is still not well understood how heterogenous ice melting is influenced by large-scale under-ice flow structures, and moreover, the contribution of bathymetry to the picture. To investigate how changes in bathymetry effect key flow features and associated ice melt, an idealized 3D lake was modelled using AEM3D. The base case simplified the parameters contributing to the under-ice circulation to focus on meteorological forcing. Shortwave radiation penetrating through the ice generated gravity currents that flowed downslope, resulting in warm upwelling in the lake centre. It was found that the shape of the ice profile was highly dependent on the shape of the lake bottom as the bathymetry dictated the lake-wide heat transport. The base case was then expanded to include Coriolis, which produced an anticyclonic gyre of warmer water at the surface, resulting in a different ice profile story. This research supports the hypothesis that the morphometry of a lake can be inferred based on the ice melt pattern observed at the surface.

George Arhonditsis, University of Toronto. **Integrating Regional Assessment with Watershed Planning and Field-level Implementation.**

Adaptive watershed management offers a pragmatic solution to the endless "trial-and-error" attempts to addressing water pollution problems from non-point sources. The appeal of this

approach is that it promotes a "learning while doing" mindset, whereby policies or operations can be regularly updated as scientific learning progressively advances. In this context, the development of multi-model ensembles addresses the fact that there is no single model to perfectly emulate the dynamics of an open environmental system. The conceptual strength of the ensemble approach lies in the notion that the joint consideration of multiple model structures and many different parameter sets within a selected model structure is the most defensible strategy to reproduce the full range of watershed dynamics. The main pillars of this strategy, such as the rigorous assessment of the expected consequences and underlying uncertainty of management actions, and the guidance based on data generated in farms with finer granularity and synthesized with suitable quantitative tools are perfectly aligned with the policy practice of adaptive management. The proposed approach will integrate farm, watershed, and regional models to transfer information across scales and establish an open rapport among experimentalists, modellers, farmers, and a multitude of stakeholders. This broader engagement is conducive to a shift towards the Agriculture 4.0 paradigm, whereby digital technologies will guide precision and smart farming to increase production, reduce costs, optimize the use of resources, and eliminate environmental risks.

Paige Arieno, Jayson Kucharek, Nicole Fuller, Evan Batte, Steven Day, Nathan Eddingsaas, Matthew Hoffman and Christy Tyler, Rochester Institute of Technology. **Input of Anthropogenic Debris Across a Rural to Urban Gradient in the Watershed of the Rochester Embayment.**

Anthropogenic debris, including plastic, is problematic in the Great Lakes, but little is known about sources 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 two methods: LittaTraps installed in stormwater drains in urban and suburban areas, and modified trawls deployed in rural and suburban streams. Collected debris was weighed, sorted by material, and characterized by use. Debris was comprised of plastic, glass, metal, paper, organic matter, and composite items, with high spatial and temporal variability in composition and abundance. Plastic was the most abundant material. Some variation resulted from surrounding landscape characteristics: plastic and metal were more abundant in commercial-urban areas and organic debris were more abundant in residential - suburban areas. Overall input appeared driven by precipitation. Very little macro debris was transported in tributaries, but microplastic concentrations were high and related to land use. Results suggest debris mitigation measures should be targeted towards urban commercial areas. Future research will assess the impact of shifting weather patterns on debris input across the landscape. With these data and in collaboration with the community and policymakers, we will propose action-based solutions and public policy.

Isaac Armstrong[1, 2], Emma Graves[1, 2], Jamie Would[1, 2], Isabelle Pawlowski[1, 2] and Brian Cumming[1, 2], [1]Queen's University, [2]Paleoecological Environmental Assessment and Research Laboratory. **Long-term zooplankton change driven by multiple stressors in the Bay of Quinte Area of Concern.**

The Bay of Quinte, Lake Ontario, is an Area of Concern which experienced cultural eutrophication in the early-to-mid 20th century. Phosphorus abatement actions and the establishment of invasive dreissenid mussels transitioned the system to a clear state by 1995. Currently, declining nutrient concentrations and benthification processes have undermined the stability of the pelagic food web, which is now characterized by degraded plankton populations and decreased productivity. Understanding long-term change in lower trophic levels is crucial to inform management actions and contextualize modern-day observations. To characterize temporal trends in the lower food web, we examine cladoceran remains in four dated sediment cores (representing ~40 to ~100 years) from the Bay of Quinte. We describe historic background conditions, assess lower food web response to

successive ecological impacts, and compare trends between environmentally distinct basins. All four sediment cores show marked change in multiple cladoceran metrics (species composition, diversity, production, and morphology) associated with historic ecological shifts. Preliminary results indicate that pelagic productivity in the bay remains impaired in comparison to pre-disturbance conditions while benthic production has increased. Additionally, recent changes may represent a reversal of long-term recovery patterns, presenting a concern for management objectives.

Anthony Arnold[1, 2], Samuel Pecoraro[3], Jennifer Morris[2], Angus Galloway[2], Phillip Wernette[2], Alden Tilley[2], Nicholas Yeager[2] and Peter Esselman[2], [1]Michigan Technological University - Great Lakes Research Center, [2]United States Geological Survey - Great Lakes Science Center, [3]United States Fish and Wildlife Service. **Leveraging Multi-band Backscatter, AUV Imagery and AI to Detect and Enumerate Invasive Dreissenid Mussels.**

Multibeam echosounder surveys can be used to gather a variety of physical lakebed properties including bathymetry, substrate, and habitat characteristics, by comparing the backscatter and signal intensity to ground truth data which may provide a better understanding of the aquatic habitats and the benthic communities that reside there. We demonstrate the efficacy of this remote sensing technique to aid in the detection and quantification of dreissenid mussels and nuisance algae as part of an effort to monitor the quality of critical spawning habitats. We also discuss the advantages of Multi-band Backscatter (MBB), which returns low and high frequency signals from the same echo beam, further enhancing our ability to discern substrate types and aquatic species. This presentation will demonstrate how advanced backscatter mapping techniques used in a joint NOAA-USGS case-study helped to detect and enumerate invasive mussels at long-term research sites. Our findings suggest that MBB data, when paired with underwater imagery, can be used to train machine learning models to detect mussel presence with moderate accuracy and precision. With further improvements, our results indicate MBB can help us to quantify dreissenid mussel abundances at a regional scale in our habitat monitoring efforts throughout the Great Lakes basin.

Aubrey Arnt[1], E. Anders Kiledal[2], Gregory Dick[1, 3] and Riley Ravary[1], [1]Cooperative Institute on Great Lakes Research, [2]Department of Earth and Environmental Sciences, University of Michigan, Ann Arbor, MI, [3]Department of Ecology and Evolutionary Biology, University of Michigan, Ann Arbor, MI. **User-Informed Development of GLAMR: Collaborative Design of a Great Lakes 'omics Data Platform.**

The collaborative efforts of NOAA's Great Lakes Environmental Research Laboratory (GLERL) and the University of Michigan's Cooperative Institute for Great Lakes Research (CIGLR) have manifested in the development of the Great Lakes Atlas of Multi-omics Research (GLAMR). Advancements in 'omics collection methodologies have resulted in large datasets and unprecedented insights into Great Lakes ecosystems. This has posed challenges in terms of efficient storage and analysis. GLAMR, designed as a user-friendly public web interface, effectively bridges this gap by facilitating the exploration of relationships within 'omics, environmental, and biological data. In this project, Research Engagement Specialists employ a collaborative design approach to engage stakeholders and end-users throughout the developmental stages. Leveraging social science methodologies, these specialists systematically assess user needs, database usability, and identify potential collaborators. The adoption of a co-design process ensures that project deliverables align seamlessly with the requirements of end-users. Various data-gathering methods, including surveys, interviews, and, primarily, workshops, were employed to inform the product design, with continuous communication and updates provided to stakeholders. Our goal is for the cumulative input from participants to sculpt GLAMR into a robust platform that not only facilitates powerful 'omics data

discovery and exploration but also encourages collaboration and serves as a valuable resource for building cohesive relationships within the 'omics community. The implications of this project extend beyond research, with potential benefits for broader societal practices in the Great Lakes region.

Christine Atuhaire and Anthony Gidudu, Makerere University. **Remote Sensing for Monitoring Lake Victoria Water Quality: Challenges, Achievements and Future Research.**

Lake Victoria is the largest freshwater lake in Africa and the second largest freshwater lake in the world. It covers an expansive area of 68,800 km^2 and is shared by three countries (Uganda, Kenya, and Tanzania). This transboundary lake provides a wealth of ecosystem services to over 45 million inhabitants in its basin, including freshwater for domestic and industrial use, fisheries, flora and fauna habitats, and carbon sequestration. However, human activities within the basin and the effects of climate change have negatively impacted lake water quality. Traditional water quality monitoring methods are impractical for this large lake because of their high cost, labour-intensive nature, time-consuming processes, and limitations in sample collection. This has prompted the use of satellite imagery to complement in-situ monitoring efforts. Our research focuses on comparing in-situ measurements with satellite-derived water quality parameters, such as lake surface temperature, chlorophyll-a, and water clarity, using MODIS and Sentinel satellite imagery. We also developed chlorophyll-a algorithms tailored to Lake Victoria to evaluate trophic status using MODIS imagery. Although satellite imagery offers a synoptic view of the lake and multiple measurements per week, further investment is needed to develop suitable models for widespread acceptance among stakeholders and decision-makers. This presentation will provide insights into the challenges, achievements and future research avenues for using Earth observations to monitor the water quality in Lake Victoria.

Daniel Sandborn and **Jay Austin**, University of Minnesota, Duluth. **Patterns of Lake Superior AIS dispersal illustrated by particle tracking.**

A particle tracking model was deployed to simulate dispersal of aquatic invasive species (AIS) in Lake Superior, with a particular emphasis on *Dreissenia spp.* recently observed far from known populations. This work combined freely-available hydrologic model output with open-source particle tracking software to illustrate patterns of transport from potential source populations to onshore and offshore accumulation "hotspots". Transport was driven mainly by prevailing currents yet significantly modified by stochastic events such as windstorms. Characteristic timescales of particle transport were found from connectivity matrices, which demonstrated lake-wide hydrological connection on sub-annual scales. The fate and transport of particles on scales less than this period depended upon when and where particles entered the system, highlighting the utility of particle tracking to illustrate patterns of particle dispersal as a function of space and time. This research laid the groundwork for development of particle tracking models spanning the Laurentian Great Lakes with predictive capacity applicable to AIS, microplastics, harmful algal blooms, and point-source pollution events.

Khoren Avetisyan, Xiaoqing Shao, George Arhonditsis and Maria Dittrich, UTSC.
Biogeochemical Dynamics in the Water Column of Hamilton Harbour (Lake Ontario).

This study, conducted across Hamilton Harbour at various locations and dates during 2023, focusing on the pivotal role of phosphorus (P) in the complex interplay with iron (Fe), manganese (Mn) and other biogeochemical parameters of the water column. Sampling was carried out at multiple locations including Station 1001, Station 9031, Windermere Basin, and Skyway WWTP, across a span from May 25th to October 12th. The methods used in the Hamilton Harbour study

include spatial and temporal variations in physical measurements such as dissolved oxygen (DO), temperature, pH, photosynthetically active radiation (PAR), conductivity, chlorophyll, salinity, alkalinity and turbidity. Chemical analyses such as soluble reactive phosphorus (SRP), total phosphorus (TP) polyphosphates (PolyP), activity of alkaline phosphatase (Aphase), and oxygen isotopic composition of phosphate (^{18}O-PO_4). Concentrations of dissolved iron and manganese, ammonium, total organic carbon and total nitrogen, nitrate, methane, carbon dioxide, sulfate, total metals (ICP-OES), DNA sequencing for microbial community analysis, Scanning Electron Microscopy with Energy Dispersive X-ray Spectroscopy (SEM-EDX) for detailed particulate analysis. These varied measurements provide a multidimensional perspective on the Harbour's environmental state, facilitating a deep understanding of its current conditions. The study revealed significant spatial and temporal variations in soluble reactive phosphorus, total organic carbon, total nitrogen, and trace elements such as Al, Fe, and Mn. Understanding these interactions is crucial for assessing Hamilton Harbour's ecological condition and guiding effective environmental management strategies.

B

Michael Back[1], Grace Watson[1], Erica Horton[1], Hana Esber[1], Emily Campbell[1], Justin Myers[2], Silvia Newell[3] and Lauren Kinsman-Costello[1], [1]Kent State University, [2]Wright State University, [3]University of Michigan. **Sediment-surface water nutrient exchange across vegetation patches in a diked Lake Erie wetland.**

Diked coastal wetlands along the Great Lakes have stable water levels between management actions; however, internal nutrient processing can vary across a wetland and lead to net nutrient release or retention associated with shifts in hydrology via management. Determining the direction and rate of nutrient exchange at the sediment-water interface of a diked coastal wetland can indicate the potential nutrient release upon a shift in management actions. We asked how nutrient flux varies at the sediment-water interface across vegetation patches of a diked wetland? And, how *in situ* and *ex situ* methods of measuring nutrient flux compare? We measured sediment-water nutrient flux ($mg/m^2/d$) using intact sediment core incubations (*ex situ*) and stacked-resin bag core deployments (*in situ*) across five distinct vegetation patches in a diked wetland on the southwest coast of Lake Erie. In intact sediment cores, soluble reactive phosphorus fluxes range from -10.6-11.1, nitrate fluxes range from -2.9-4.2, and ammonium fluxes range from -3.9-151.8 (negative fluxes indicate net transfer from surface waters to sediments). Nutrient flux values are higher in intact cores than stacked-resin bags, which could be attributed to the discrepancy of the temporal scale captured by the two methods (3 vs 10 days, respectively) or by confounding variables occurring *in situ* which are excluded *ex situ*. Understanding how sediment-surface water nutrient exchange varies spatially and temporally can guide management decisions in Great Lakes wetlands.

Jim Bader[1] and **Shari Insley**[2], [1]Case Western Reserve University, [2]Pine Intermediate School. **Expanding citizen science with university/school partnerships.**

Most citizen science programs include motivated adults with commitments to preserve natural resources. Elementary and high school students are citizens too and many have the similar commitments to the environment. Partnerships between universities and schools already exist in many different forms. In this presentation, we describe the path we have taken in NE Ohio to marry informal citizen science education with formal school-based education. Specifically, we will present

work on how we linked schools to the Cleveland Water Alliance's Lake Erie Volunteer Science Network and continue to support school-based, water focused monitoring programs.

Kerrice Bailey[1], Kevin Blagrave[1], Aman Basu[1], Nadine Benoit[2], Todd Howell[2] and Sapna Sharma[1], [1]York University, [2]Ontario Ministry of Environment, Conservation and Parks. **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.

Anna Baker[1], Rebecca Kreiling[2], Carrie Givens[1], Richard Kiesling[1], Eric Dantoin[1], Patrik Perner[1], Shelby Sterner[1], Krimson Anderson[1] and Gerald Storey[1], [1]U.S. Geological Survey Upper Midwest Water Science Center, [2]U.S. Geological Survey Upper Midwest Environmental Sciences Center. **Linking tributary nutrients, sediment, and cyanobacteria to Lake Superior nearshore algal blooms.**

Lake Superior, the most oligotrophic of the Laurentian Great Lakes, has experienced repeated nearshore cyanobacterial blooms along its southwestern shore over the past decade. Previous studies suggest that storm-driven fluxes of nutrients, sediment, and cyanobacteria may play an important role in driving these blooms. To investigate further, the U.S. Geological Survey participated in a large multi-institution partnership under the Collaborative Science and Monitoring Initiative. We focused on two key tributaries to south-shore Lake Superior, the Bois Brule and Siskiwit Rivers, and collected streamflow, discrete and continuous water quality, sediment-nutrient cycling, and microbial genetics data. Relationships between streamflow and concentrations of suspended sediment, total phosphorus, and total nitrogen were evaluated using regression models. Statistical analyses confirmed that these parameters increase with increasing streamflow, and also indicated that concentrations of total phosphorus increase with suspended sediment, suggesting that suspended sediment may serve as a vector for phosphorus transport from tributaries to the nearshore. Furthermore, sediments collected from the water column and streambed were analyzed for their potential to bind and release phosphorus. Results showed variability interannually, upstream to downstream, and between tributaries, and suggested that sediment may serve to bind phosphorus from the water column within the stream environment, but may have the potential to release this phosphorus downstream in the nearshore. Evaluation of microbial community dynamics also indicated temporal variation in communities present, which may be linked to nutrient availability.

Vanessa Baker, Nathan Eddingsaas and Christy Tyler, Rochester Institute of Technology. **Impacts of *Dreissena* polymorpha on the fate of plastic debris.**

Dreissena polymorpha (zebra mussel) is a freshwater invasive species that colonizes a variety of hard surfaces, including plastic debris. Plastic pollution is an increasing problem in freshwater

ecosystems, but the fate and impact is poorly understood, especially for initially buoyant polymers. Floating plastic can be a vector for invasive species spread, but the impact of fouling on fate and transport is also unknown. We examined the effects of *D. polymorpha* colonization on the fate of two buoyant polymers with three different textures. Swatches of polystyrene cups (PS), polypropylene masks (PPM), and polypropylene sheets (PPS) were incubated in a small lake in the Lake Ontario watershed for 19 weeks. Sheets were oriented horizontally to evaluate orientation impacts on colonization and degradation. Control polymers were periodically cleaned of all fouling organisms. Mussels colonizing the top and bottom of each plastic were counted separately and divided by size class. Impacts of colonization on plastic degradation were assessed using Fourier Transform Infrared Spectroscopy (FTIR). *D. polymorpha* density was highest on PPM and PS, with greater numbers on the side facing the benthos. Oxidation was higher where *D. polymorpha* did not accumulate. These results suggest that *D. polymorpha* fouling on buoyant materials such as PP and PS may decrease polymer degradation and promote vertical transport, influencing the temporal and spatial fate of plastic in freshwater ecosystems.

Mitchell Barklage, Prairie Research Institute - Illinois State Geological Survey. **Sub-bottom Geophysical Imaging of Greater Chicago's Lake Michigan Coastal Zone.**

Recent efforts to generate high-resolution, high-density bathymetry maps of the Great Lakes coastal region have greatly increased our knowledge of the nearshore lake-bottom environment. While these federal LIDAR-based datasets have revealed lake-bottom physiography in unprecedented detail, a lack of sub-surface geological information persists that would enable stratigraphic framework modeling. Here we present the results of the first sub-bottom geophysical imaging campaign since the early 1990s focused on greater Chicago's Lake Michigan coastal zone. We acquired ~165 track line km of seismic reflection imagery using an Edgetech 3400-OTS sub-bottom profiler. This was supplemented with ~85 track line km of ground-penetrating radar (GPR) imagery, acquired with a GSSI 200 MHz system. Offshore sediment cores (n=20) were collected at key locations to help ground-truth geophysical interpretations. These subsurface data provided the necessary information to reconstruct the three-dimensional stratigraphic framework of the Chicago coastal zone. Data-derivative products include maps of surface geology and sand thickness. Our results show there is a greater volume of offshore sand along the city's North Side and that urban infrastructure and exposed dolomite bedrock shoals act as barriers to north-south sand migration. Sand deposits are typically thickest within urban lakefront embayments and decrease in thickness from pocket beaches lakeward, transitioning to thin sheets averaging 0.5-1m thick within 500m of the shoreline. These observations provide valuable constraints for understanding sand-transport processes and beach geomorphic response to changing lake levels.

Isabelle Barrette-Ng[1], Adam Clare[2], Trevor Pitcher[1], Catherine Febria[1] and Cameron Proctor[1], [1]University of Windsor, [2]Sheridan College. **myWATERSHED: Accelerating sustainability stewards of the future.**

Traditional classrooms offer students limited opportunities to plan and implement restoration due to barriers of ecological, spatial, and temporal scale. However, with agency and access to authentic datasets, it has been shown that learners can problem-solve, develop interdisciplinary skills, enhance cross-cultural competencies, and most importantly: (re)-connect to nature and its restoration from diverse perspectives. To train and empower youth to take on the challenge of ecological restoration and reconnect with nature in a transformational way, a multidisciplinary team created the myWATERSHED sandbox game. myWATERSHED utilizes a digital twin of the Humber River watershed to provide learners with the opportunity to engage

actively in restoration using a real-world endangered species, the redside dace. The game creates a realistic simulation where the interactions explore ecological principles and critical challenges, including the concept of spatial, temporal and ecological scale in restoration. myWATERSHED allows students to explore and manipulate a realistic environment where they can assess different restoration strategies, implement different efforts under resource constraints, and solicit feedback. In this presentation, we will describe: (1) the effects of playing the game on students' perceptions of the value of restoration ecology, and their understanding of the factors that influence the success of restoration strategies; and (2) how best to measure the effects of simulations and game play on student learning and meaning making.

Lauren Barth[1], Todd Howell[2] and Don Jackson[1], [1]University of Toronto, [2]Ministry of Environment Conservation and Parks. **High wintertime phosphorus export from Lake Ontario tributaries across a gradient of urbanization.**

The pulse of phosphorus from watersheds to large temperate lakes and their fate in the nearshore is strongly linked to seasonality. Additionally, urbanization in the watershed changes flow dynamics and provides novel point and diffuse sources of contaminants that confounds the seasonal signal. Here, we used a combination of event-based composite and low-flow grab sampling of thirteen Lake Ontario tributaries along a ~140 km stretch of the Canadian shoreline from 2018-2023 to investigate the timing and magnitude of phosphorus pulses to the nearshore and how this varies with urbanization. Across tributaries, winter concentrations of dissolved (DP) and particulate (PP) phosphorus were as high, or higher, than those observed in spring. Combined with high flows, there was a large flux of phosphorus to the lake during cold winter months. The majority of phosphorus coming into Lake Ontario was in the particulate form (range of median %PP across tributaries = [76,94]). Consequently, the PP delivered to the lake during winter will be concentrated in the dreissenid mussel beds in the nearshore zone due to strong shore parallel currents potentially fueling spring algal growth. The highly urbanized tributaries exhibited elevated concentrations and loadings of DP and PP through all seasons and likely have the greatest impact on Lake Ontario's nearshore community as they provide a relatively consistent flux of elevated phosphorus to the nearshore zone.

Abigail Comar[1, 2] and **Jill Bartolotta**[1, 2], [1]Ohio Sea Grant, [2]The Ohio State University. **BOTtttle: Engaging with underserved and underrepresented students to pilot marine debris removal technologies.**

Beach and On-water Trash Trapping Tech Team for Lake Erie (BOTtttle) is a partnership with Ohio Sea Grant and Cuyahoga Community College's Advanced Technology Training Center (ATTC) and is supported with funding from Meijer Incorporated and National Oceanic and Atmospheric Administration Climate-Ready Coasts Program, Bipartisan Infrastructure Law. The ATTC works with underserved and underrepresented students in the Cleveland area to offer educational programming and workforce development opportunities in the STEM disciplines. We are working together to engage Cleveland youth in Lake Erie stewardship activities, introduce them to the issue of marine debris in their local community, and utilize their expertise with robotics to effectively operate and manage the recently acquired trash removal technologies, BeBot and Pixie Drone. Students are receiving relevant job training and field experience in the rapidly growing green jobs and marine debris removal technologies sector. In addition to robotics care, operation, and maintenance, students support waste characterization efforts to learn more about data collection and management protocols. Interactive programming engages youth with their coastal environment

empowering them to care for Lake Erie. Our presentation will share lessons learned, funding streams, program results, and student stories.

Rose Basooma[1, 2], Judith Namumbya[1, 3], Vianny Natugonza[2], Wolfram Graf[1] and Harald Meimberg[1], [1]University of Natural Resources and Life sciences, [2]Busitema University, Department of Natural Resources and Environmental Sciences, [3]Ministry of Water and Environment. **Unveiling the Potential: Exploring Challenges and Opportunities in Molecular Methods for Monitoring Ecological Health of Wadable Streams in Uganda and East Africa with Macroinvertebrates.**

Freshwater ecosystems support biodiversity and ecological services. Despite these benefits, they have been degraded immensely. Monitoring the health of these ecosystems is vital. Macroinvertebrates are already widely used to assess biodiversity and ecological health. Recent advancements in DNA-based techniques have shown promising results in detecting species across various ecosystems due to reduced processing time, enhanced taxonomic resolution, and decreased errors compared to morphological methods. These DNA-based methods encompass the use of homogenized samples, DNA extracted from sample preservatives, and environmental DNA from water or sediment. This review explores the challenges and opportunities associated with advancing molecular methods for routine biomonitoring. Challenges identified include limited awareness and understanding of molecular techniques, financial constraints, and the need for capacity building in molecular biology skills. Standardized protocols and comprehensive DNA databases for East African regional macroinvertebrate species are lacking, hindering broader acceptance of molecular approaches. Despite these challenges, the review highlights promising opportunities. Collaborative efforts between research institutions, governmental agencies, and non-governmental organizations are crucial for knowledge exchange and capacity building. Financial support can aid in acquiring molecular biology equipment and training programs. Standardization of protocols and the development of DNA reference databases can be achieved through concerted research efforts and regional cooperation. The review serves as a call to action for the scientific community, policymakers, and environmental practitioners to collaborate in advancing molecular approaches for effective freshwater biomonitoring in the region

Aman Basu, Joshua Culpepper, Kevin Blagrave and Sapna Sharma, York University. **Changes in lake ice phenology in the Northern Hemisphere: Past, present, and future shifts.**

Long-term ice phenology records enumerate the effects of climate change on Northern Hemisphere lakes. This study uses lake ice phenological records for a gradient of small to large lakes (0.1 to 31967.8 km 2 in lake surface area) obtained from community science networks where we compiled *in situ* ice phenological records for 2499 lakes across 15 countries for an average of 30 years. These data revealed that for the last 50 years (1971-2020), the annual mean duration of lake ice cover decreased at a rate of 7.9 days per decade, with a global acceleration in lake ice loss following the late 1980s. We forecasted that ice duration at the end of the century (2070-2099) will decrease on average 29 days when compared to the historical time period (1971-2000) for the Shared Socioeconomic Pathway (SSP) 1-2.6 climate scenario (SSP126), 43 days for SSP370, and 49 days for the SSP585 scenario. The widespread loss of ice portends ecological, cultural, and economic consequences for ecosystems and communities that depend on lake ice cover.

Nandita Basu, University of Waterloo. **Farmed wetlands: The outsized role of small agricultural wetlands in basin scale nutrient retention.**

Excess nutrients from agricultural activities have increased eutrophication of inland and coastal waters. Wetland restoration is a key strategy to improve downstream water quality by nutrient retention, while also providing other key ecosystem services (ES) (e.g., greenhouse gas reduction (GHG), biodiversity support). Farmed wetlands - depressions in croplands that have been partially drained for crop production - are a ubiquitous feature of agricultural landscapes, globally and in North America. Often these are areas of lower productivity compared to the surrounding farmland, and thus targeting them for restoration can contribute to water quality improvement without as much of an economic cost. Further, on a per unit area basis small wetlands are more efficient at nutrient retention. However, these smaller wetlands also receive less protection because of their apparent disconnectivity to downstream waters. Here, we use a combination of remote sensing and site scale wetland nutrient studies to show that these small, apparently disconnected wetlands play an outsized role in nutrient retention. We further identify wetland morphometric attributes that maximize retention. This understanding can then be used to develop scenarios for wetland restoration to reduce phosphorus loading through strategically targeting areas of high nutrient use and morphometric designs that prioritize retention.

Michael Battaglia, Laura Bourgeau-Chavez and Jeremy Graham, Michigan Technological University. **Assessment of Great Lakes Coastal Wetland Inundation Extent with Synthetic Aperture Radar.**

Fluctuating water levels in the Great Lakes have led to significant changes in coastal wetland extent. Monitoring inundation extent is important as it can drive changes in vegetation species compositions and habitat availability for fish, birds, and invertebrates, as well as having significant impacts on infrastructure and property. Remote sensing is a valuable tool for assessing dynamic inundation extents in coastal systems, but limitations due to cloud and vegetation canopy coverage make estimating inundation difficult with optical imagery. Synthetic aperture radar (SAR) sensors, which utilize microwave wavelengths, are capable of collecting imagery regardless of cloud cover and are able to penetrate vegetation canopies. An automated algorithm has been developed to detect open surface water and flooded vegetation extent using C-band SAR data from the Sentinel-1 constellation. The algorithm has been implemented in a cloud computing environment to enable efficient processing of large geographic regions such as the coastal Great Lakes. The algorithm has been run for each month in the growing season from 2017 - 2023, allowing us to assess the impact record high water levels have had on coastal inundation and emergent wetland vegetation. This approach highlights a repeatable methodology that can provide important information for long term wetland monitoring in the Great Lakes region.

Evan Batte[1], Paige Arieno[1], Nikki Fuller[1], Jayson Kucharek[1], Steven Day[2], Matthew Hoffman[3], Christy Tyler[1] and Nathan Eddingsaas[4], [1]Gosnell School of Life Sciences, Rochester Institute of Technology, [2]Department of Biomedical Engineering, Rochester Institute of Technology, [3]School of Mathematics, Rochester Institute of Technology, [4]School of Chemistry and Materials Science.
Degradation of Anthropogenic Debris in the Watershed of Lake Ontario.

Anthropogenic debris (AD) is ubiquitous in the environment, yet the impact on environmental and public health in the Great Lakes watershed is not well understood. Stormwater is an important mechanism for AD movement, however vegetation and engineered stormwater management infrastructure may trap AD, reducing debris loading in the Lakes and creating hotspots of accumulation across the landscape. Little is known about the ultimate fate of AD accumulating in

these hotspots. A long-term experiment in riparian areas, stormwater ponds, and roadside stormwater catch basins was established to field-age the most commonly collected debris items: cigarette butts, polypropylene-metal chip bags, and polyethylene shopping bags. The materials were introduced to the environment in both summer and winter in order to evaluate seasonal impact on degradation. Debris degradation was assessed by measuring tensile strength, degree of oxidation (FT-IR), and biofilm development. Preliminary data indicate near total disintegration of cellulose acetate cigarette filters in catch basins after 1 year, with greater degradation overall in summer introduction than winter. Further, the degree of degradation appears to be most influenced by environment, with lower rates in the riparian zone. Materials in stormwater ponds have the most highly developed biofilms. These experiments will allow us to better understand the fate of AD accumulating in these hotspots and more accurately estimate debris loading into Lake Ontario.

Masoumeh Bavadi, Xing Song, Bing Chen and Baiyu Zhang, Memorial University. **Formation of the Next-Generation Dispersant by Using both Biosurfactants and Chemical Surfactants.**

Oil spills, posing significant ecological threats worldwide, have encouraged extensive research into innovative spill response options. One prominent method involves dispersants (i.e., surfactants mixed with solvents), facilitating the breakdown of the oil slick into tiny oil droplets, enhancing the solubilization of oil components, and promoting their biodegradation. Current dispersants utilize mainly chemical surfactants. This work is focused on the production and evaluation of a next-generation dispersant product that combines both bio- and chemical surfactants. The strategy for component mixing was optimized by analysis of their interaction through molecular dynamic simulations. The new dispersant mixture exhibited remarkable performance under various environmental conditions, demonstrating its adaptability to the diverse challenges of aquatic environments. Molecular dynamic simulations further illustrated how surfactants, key components of the new dispersant, interacted with oil components through molecular interactions, including van der Waals and electrostatic interactions. These findings may facilitate the development of the next generation of dispersants, potentially reducing the impact from oil spills to aquatic environments.

Doug Beard[1], Ian Cowx[2], Steve Cooke[3] and Chris Goddard[4], [1]United State Geological Survey, [2]Hull University, [3]Carleton University, [4]Retired. **First Global Inland Fisheries Summit; or how we learned to love the number 47.**

Inland fisheries are a critical component of economic security in many parts of the world. Providing food and livelihoods, these fisheries are often overlooked during global discussions of sustainable fisheries management. Recognizing this omission as part of the overall world fisheries discussion, a group of individuals, representing inland fisheries from around the globe developed and hosted the first summit focused on inland fisheries at the United Nations Food & Agricultural Organization. Little did our leadership team realize how critical the number 47 would be to effectively organize and develop the first global inland fisheries conference. Although multiple in-person meetings were held to discuss and organize an agenda; many serious discussions were led by Dr. Taylor at a certain rooftop setting located in the Hotel 47. It was at this setting we realized the importance of intangibles that make conferences successful. And a success it was, the conference managed to pull together multiple experts from 40 countries. The conference was focused on four main themes, biological assessment, economic and social assessment, drivers and synergies and policy and governance. The ultimate outcome was the Rome Declaration: Ten Steps to Responsible Inland Fisheries. The Rome Declaration has set the science and management agenda for inland

fisheries, since its publication in 2016. All of which would not have happened with the brilliant use of official settings and unofficial trust building sessions facilitated by Dr. Taylor.

Naomi Beauchesne[1], **Tristan Cleland**[1], **Tristan Thompson**[1], **Mike Aiabens**[1], **Jeffrey Lallean**[2], **Shayenna Nolan**[2], Karen Cedar[3], Candy Donaldson[2], Catherine Febria[2] and Clint Jacobs[2], [1]University of Windsor & City of Windsor, [2]University of Windsor, [3]City of Windsor. **Co-creation with the Indigenous Youth Circle and Windsor's National Urban Park.**

The Indigenous Youth Circle collectively represent the next generation of Indigenous stewards and science practitioners all working together to guide wise protocols and practices for the National Urban Park site in Windsor and broader region. Individually they each possess gifts of language, sport, science, culture, and more. They will be training in a range of ecological monitoring practices, learning from Elders and knowledge keepers in the region, while also co-creating and engaging on new programming linked to the development of a proposed National Urban Park site. Here they will share experiences from the first year of this collaboration, including how the group came together, and how this work has connected them to teachings about water, language revitalization, and the importance of connections to local ecosystems. In particular they will share lessons learned from organizing their first land-based Indigenous Teachings day in November 2023. From logistics and grant writing to connecting, Indigenous-led science, community-led teachings and connections with local Indigenous and non-Indigenous community members, they will reflect of their journeys and personal growth. Finally, they will share visions and aspirations for the future, barriers and enablers to successful collaborations.

Happiness Beda, University of Dar Es Salaam, Clean Shores Great Lakes. **A Review on the Status of Plastic Pollution in the African Great Lakes.**

Plastic pollution is ubiquitous in freshwater systems worldwide, and the African Great Lakes are no exception. I conducted a review on the status of plastic pollution in the African Great Lakes, including macroplastics (>5mm) and microplastics (<5mm). Six publications were used to review the status of plastic pollution in the African Great Lakes based on their sources, type and ecological impacts. The most dominant sources identified were fishing activities, degradation of larger plastic materials, and anthropogenic activities. Other minor sources of plastic in the lake come from land-based activities. The type of plastics identified were fragments, filaments, films, foams, and flakes. The ecological impact of plastic pollution, shown in one paper, was microplastic ingestion in commercial fish (Nile perch and Nile tilapia). Finally, there are gaps in scientific knowledge that need to be addressed and discussed. These include a need for further research expanding our knowledge of the sources, pathways, types and impacts of plastic pollution. Community engagement, policy evaluation and scientific innovation must be done to pave the way for sustainable solutions.

Ashley Thompson, **Hannah Bekius**, Elena Tislerics, Carter Griffioen, Shelia Blackman and Pei-Lan Tsou, Grand Valley State University. **Beaches and Feces: the Journey to Solve the #2 Mystery.**

Michigan recreational beaches at risk for water-borne illnesses are routinely monitored for *E. coli* - a marker of fecal contamination. Charlton Park beach on Thornapple Lake is frequently closed because *E. coli* exceeds the State threshold, forcing the beach to close for 35 days in 2022 and 12 days in 2023. Remediation is not possible until a contamination source is determined. We partnered with Barry-Eaton District Health Department to determine the source through the molecular detection of host-specific bacteria (MST). We intensively sampled the beach and other sites around the lake, including tributary sites for five weeks and simultaneously monitored environmental

factors. Samples were analyzed for both *E. coli* and HF183. Testing showed a correlation between the *E. coli* marker EC23S and the HF183 human marker when the *E. coli* counts are high but proved difficult to correlate them at low levels. We found that contamination: is human in origin; originates from two sites upstream of the beach and; is most likely to occur when the normal southerly current in Thornapple Lake is slowed. Validation is underway with secondary markers to further confirm human origins, as well as testing the effectiveness of alternative markers. Our work attests to the important role that molecular techniques can play in the field of environmental forensics.

Ashley Belle and **Megan Gunn**, Illinois-Indiana Sea Grant. **Incorporating Virtual Reality into Environmental Education to Connect Youth to the Great Lakes.**

The Grand Calumet River Area of Concern (AOC) has experienced significant environmental degradation resulting from historical activities. Utilizing 360-degree virtual reality (VR) technology, an immersive experience was developed that allows users to travel along a segment of the Grand Calumet River in Northwest Indiana. The experience features degraded areas as well as sites that under the voluntary Great Lakes Legacy Act program have completed contaminated sediment remediation and habitat restoration to improve the aquatic and upland environment for fish, wildlife, and people. This presentation will focus on the development of the virtual reality experience and its delivery by a web-based platform and VR headsets. A Next Generation Science Standards (NGSS) aligned curriculum, targeting upper-elementary through high school students, has also been designed to complement this immersive experience. This presentation will walk through the curriculum highlighting lessons that foster critical-thinking and reflection as students learn about the environmental history of the AOC, how VR is integrated into environmental science, and the collection of field data. This VR experience can serve as a useful tool to better engage youth in Great Lakes education.

Nadine Benoit, Ryan Sorichetti, Bogdan Hlevca and Todd Howell, Ontario Ministry of the Environment, Conservation and Parks. **A multi-faceted spatial and temporal approach to Assessing Lake Ontario's Western Basin Nearshore Water Quality.**

In 2023, the Ontario Ministry of Environment, Conservation and Parks conducted a nearshore water quality study in Lake Ontario's western basin, from Oakville to Grimsby to assess conditions over this heavily urbanized coastline. Present stresses on water quality and water resources include changing landscape hydrology due to continuing watershed development and shifting weather patterns and use as a receiver of wastewater and stormwater. This study aims to broadly characterize spatial and seasonal features of water quality and physical conditions in the immediate nearshore zone most affected by land, extending 5km into the lake. Design elements include: 1) spatially-intensive collection of sensor and discrete chemistry data to define alongshore and onshore-offshore patterns in water quality; *2)* through-time collection of physical and surrogate water quality data using instrumentation placed over the study area to characterize the changeable physical conditions influencing water quality; 3) integration with event-monitoring of tributary loading to the nearshore of the western basin to gauge inter-play between river discharges and nearshore conditions; and, 4) hydrodynamic and water quality modeling to support integration of point in-time and through-time data to aid interpretation. Our presentation will outline how this work intends to inform on present conditions shaping water quality at the land - lake interface framing expectations into the future. We anticipate future land-to-lake gradients may further intensify due to offshore oligotrophication, changing wind dynamics impacting broader lake circulation, and urbanization pressures.

Nicole Berry[1], Erin Overholt[2], Jennifer Schumacher[2], Kristopher Dey[3], Jason Smith[4], Michael Diefenbach[5], Craig Williamson[2] and David B. Bunnell[1], [1]USGS Great Lakes Science Center, [2]Miami University, [3]Little Traverse Bay Bands of Odawa Indians, [4]Bay Mills Indian Community, [5]Northern Michigan University. **UV exposure induces hatching of Adikameg eggs.**

Adikameg (Lake Whitefish, *Coregonus clupeaformis*) serve important ecological, cultural, and economic roles within the human and greater-than human communities of the Great Lakes. Adikameg are decreasing in Lake Michigan, potentially as a result of low recruitment success hindered by an increase in underwater exposure to damaging ultraviolet radiation (UV; 320 - 400 nm). Both the spread of non-local *Dreissena* mussels, which decreased the basal food web and increased water transparency, and the simultaneous loss of ice cover may increase UV exposure during Adikameg egg development. Additionally, hatchery managers who have a decade-long relationship observing Adikameg, noted that light exposure can induce hatching. Our laboratory experiments found that a single day's exposure of UV can induce hatching up to 30 days earlier than controls. Two hypotheses explaining the relationship of UV-induced hatching include: 1) Adikameg embryos detect UV and initiate escape hatching behavior to avoid UV exposure, and 2) UV-induced hatching is an adaptive strategy that under historic conditions, would have corresponded with spring ice-out and abundant prey resources. Under current conditions, however, earlier hatching may lead to enhanced starvation after hatching if prey resources are not readily available (due to the depleted basal food web, or a mismatch in spring emergence of suitable prey). This talk expands on the results of our laboratory experiments investigating the UV-induced hatching phenomenon in Adikameg eggs.

Kezzy Besa, Lilongwe University of Agriculture and Natural Resources / University of Zambia. **Investigating Heavy Metal Pollution in Fish, Water, and Sediments in Lumwana East River, Northwestern Province, Zambia.**

In Zambia, the fisheries and Aquaculture sector contributes significantly to food security, self-sufficiency and livelihood, having contributed 3.2% to the national GDP in 2016. Overall, fish accounts for about 40% of protein intake in rural parts of the country and it offers alternatives for better nutrition, income generation, and job development. Despite Zambia's abundant water resources, it remains a net importer of fish, pointing to challenges in bridging the production-population gap. Aquatic life faces threats from pollution, primarily attributed to mining and other anthropogenic activities. Heavy metals are among the pollutants of concern due to toxicity and bioaccumulation characteristics. The mining sector, a cornerstone of Zambia's economy, brings both economic benefits and environmental challenges, notably aquatic pollution. This pollution poses a direct threat to aquatic environments, impacting fish health and, consequently, human health through the consumption of contaminated fish. The study focuses on Lumwana East River, a region with limited scientific attention despite the escalating mining activities around it. It aims to establish baseline data on metal accumulation, providing crucial insights for policymakers and regulatory bodies to formulate effective management and remediation strategies in the Northwestern Province. The research specifically targets the assessment of heavy metal concentrations in water, sediments, and fish species across different locations along the river. This comprehensive investigation seeks to contribute valuable information to safeguard the delicate balance of aquatic ecosystems and ensure sustainable resource management.

Huifang Bi, Chunjiang An and Catherine N. Mulligan, Concordia University. **Exploration of a bio-based coating strategy as an oil spill response countermeasure.**

Spilled oil in freshwater environments can generate significant, long-term, detrimental effects on shorelines due to its environmental persistence and toxic effects. Hence, consideration is given to the development of an efficient and sustainable oil spill countermeasure for the protection of shorelines. In this study, an alginate-based coating with a unique surface structure and superhydrophobic properties was developed to reduce the extent of freshwater shoreline oiling. First, the hydrogel coating for the freshwater shoreline substrates was prepared based on the reaction of alginate, crosslinking agents (polylysine and chitosan solutions), and other additives (e.g., cellulose nanocrystal) to endow the surface of shoreline substrates with the oil-repellent properties, and its optimized formulation was determined for following experiments. Second, the optimal coating was characterized through contact angle measurement, scanning electron microscope (SEM), Fourier-transform infrared spectroscopy (FTIR), and surface free energy analysis to reveal its oil repellence mechanism. Then, the effectiveness of the bio-based coating as an oil spill response was comprehensively investigated through a series of laboratory tests (oil adhesion tests and oil removal tests) under various environmental conditions, including different substrates, oil types, salinity, and temperature. Finally, the bio-based coating strategy was discussed for its potential application in various freshwater shorelines, such as concrete retaining wall/ boat ramp, riprap, boulders, and cobbles.

Bopi Biddanda[1] and Steve Ruberg[2], [1]Gand Valley State University, [2]NOAA-Great Lakes Environmental Research Laboratory. **Karstic Chronicles: Two Decades of Exploration of Submerged Sinkholes in the Great Lakes.**

Serendipitous findings of salty water in the bottom of Lake Huron in early 2001 led to multiinstitutional scientific exploration and discovery of numerous submerged sinkhole ecosystems in Lake Huron in the ensuing 2 decades. Here, modern-day benthic microbial mats, resembling those of early Earth and that of deep-sea vents (and possibly mat worlds we may encounter on extraterrestrial hydrospheres), inhabit low-oxygen, low-pH, high-sulfur, groundwater-fed submerged sinkholes. Photosynthetic cyanobacteria dominate shallow sunlit sinkholes, whereas chemosynthetic microbes run the aphotic sinkhole ecosystems. Towards the end of each day, mats produce net oxygen - a feature that may have led to net oxygenation as the daylength increased to >21 hours in the last 400 million years. Additionally, alternating daily vertical migration of phototactic cyanobacteria and chemotactic chemosynthetic microbes across the 1-mm thick mat-sediment interface appears to optimize such net oxygen evolution and promote carbon burial. Several sinkhole unknowns persist including: abundance and distribution of sinkhole ecosystems in the Great Lakes basin and other karst based limnetic systems globally, mechanisms of recharge and flow of groundwater aquifers feeding distant sinkholes, the age of venting groundwater, mechanism of colonization and dispersal mat filaments in geographically isolated sinkholes, pharmacological potential of bioactive compounds, and the significance of sinkhole biodiversity to biospheric biodiversity and physiologic function - and emphasize the need for their further study and conservation.

Emma J. Bloomfield, Sarah S. E. King, Sofia C. Pereira, Brent W. Metcalfe, Aaron T. Fisk and Timothy B. Johnson, Ontario Ministry of Natural Resources and Forestry - Glenora Fisheries Station. **Seasonal trophic ecology of lake whitefish in Lake Ontario.**

Lake whitefish (*Coregonus clupeaformis)* are an ecologically, culturally, and economically important species in Lake Ontario. Lake whitefish abundance and condition declined in the 1990s

following the establishment of dreissenid mussels. These declines were largely attributed to the loss of *Diporeia*, a benthic amphipod that was an important prey item. Additional ecological changes have occurred since the loss of *Diporeia*, including round goby (*Neogobius melanostomus*) invasion and continued offshore oligotrophication. The impacts of these more recent ecological changes on lake whitefish diet in Lake Ontario are largely unknown. We investigated lake whitefish's seasonal trophic ecology using monthly (April - December) analyses of stomach contents and stable isotope ratios ($\delta^{13}C$ and $\delta^{15}N$). Lake whitefish diet is seasonally variable and includes round goby. Piscivory (beyond eggs) has historically been rare, and consumption of round goby has not been reported previously in Lake Ontario lake whitefish. Results will be interpreted with respect to energy budget and implications for lake whitefish condition and growth.

Serghei Bocaniov, Chris Houser, Zahra Akbarzadeh and Philippe Van Cappellen, University of Waterloo, Waterloo, Ontario. **Re-eutrophication of large lakes: intensification of shoreline erosion as a potentially important source of additional phosphorus loading (a case study of the central basin of Lake Erie).**

Despite significant reductions in external phosphorus (P) inputs since the 1970s and the subsequent ecological improvements, from mid-late 1990s Lake Erie has been shown signs of re-eutrophication symptoms that cannot be fully explained by changes in P inputs from the lake's watershed and connecting channels alone. This may indicate that other, previously unaccounted for, sources of P play a role in driving the lake's re-eutrophication but also that the relative importance of these sources may have been increasing over the past few decades. One such source that has the potential for a sizeable and lake-wide impact on lake P dynamics and standing stock is sediment resuspension and coastal erosion. In this presentation we will introduce new estimates of P loading to the central basin of Lake Erie from coastal erosion and assess the major driving forces. For the latter, we first analyze the storm-induced onshore winds and wave characteristics in the central basin. Next, we link them to storm-induced geomorphic changes to coastline and the along- and cross-shore mass transport of eroded bulk material. We further estimate the P load associated with the bulk eroded material based on field observations and explorative numerical modeling, and compare the load with that emanating from the watershed from all known external sources. Finally, we discuss some of the impacts of our findings for the possible future changes in the Lake Erie P cycle.

Alireza Ghane and **Leon Boegman**, Queen's University. **Fate and transport of PO4 during winter in a small temperate lake located in the Great Lakes watershed.**

Many temperate lakes accumulate sediment derived orthophosphate (PO_4) in their hypolimnion during late-summer deep-water hypoxia. In dimictic lakes, fall turnover will mix the PO_4 through the watercolumn. However, the fate and transport of this primary production limiting nutrient, during winter, is unknown. Does it remain available for the spring bloom, and why does it not trigger a fall bloom? We conducted field observations and supplemented these with three-dimensional physical biogeochemical numerical simulations to gain a deeper understanding of PO_4 transport and cycling within a small temperate lake from 2011 to 2020. Our focus was particularly on the often-ice-covered season between fall and spring turnover events. We found, the sediment derived PO_4 to be only a small portion (~1%) of the total PO_4 load. The majority being derived from mineralization and tributary inflows. The accumulated hypolimnetic PO_4 increased the watercolumn concentration during fall turnover, but a fall bloom was not initiated, because the associated mixing transported phytoplankton beneath the photic zone. This PO_4 remained available

in the water column during winter and combined with mineralized PO_4 to initiate the spring bloom, in a thin stable layer beneath the ice, as solar radiation increased seasonally during spring.

Jose Bonilla-Gomez, Adam Kowalski, Daniel Cunnane and Ethan Buchinger, U.S. Fish and Wildlife Service. **Cisco fever in Saginaw Bay, a multi-agency effort seeking to restore a native species.**

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. As a result, the Lake Huron Committee initiated a multi-agency, Saginaw Bay reintroduction effort in 2018 that has resulted in the annual stocking of one million fingerlings Cisco reared by U.S. Fish and Wildlife Service, using northern Lake Huron populations as the gamete source, to restore Cisco populations in the main basin. Oxytetracycline (OTC) marks administered prior to stocking differentiated Spring or Fall stocking release events. Fishery managers strongly supported new research and monitoring that can measure estimate relative survival to maturity, and locate active spawning sites. The study goals included assessing the extent to which reared Cisco survive to maturity in Saginaw Bay, determining if cultured Cisco return to Saginaw Bay to spawn, and evaluating Saginaw Bay Cisco reproduction. Since 2021 we used targeted surveys to collect juvenile and adult Cisco along Saginaw Bay. Until now 62 individuals have been recaptured with OTC marks (93.5% Spring, and 6.5% Fall), and additional 9 individuals were wild (no marks). Specimens were found just outside of the mouth of AuGres River. This work has documented for the first time adult stocked Cisco surviving to maturity and returning to historical spawning locations based on OTC presence.

Harvey Bootsma[1], Rae-Ann Eifert[2], Emily Lou Lamartina[1], Qian Liao[1], Cary Troy[3] and Hank Vanderploeg[4], [1]University of Wisconsin-Milwaukee, [2]Wisconsin Department of Natural Resources, [3]Purdue University, [4]NOAA / Great Lakes Environmental Research Laboratory. **Deep Learning: How profundal quagga mussels affect Lake Michigan phosphorus and plankton dynamics.**

Within most of the Great Lakes dreissenid mussels are known to be major consumers of phytoplankton and recyclers of nutrients. While many studies have quantified dreissenid excretion of dissolved nutrients, egestion of particulate nutrients in the form of biodeposits has received less attention. We conducted experiments to quantify and determine the fate of phosphorus egested by profundal quagga mussels in Lake Michigan. We found that egestion can account for 15-70% of total P released by mussels. During 3-week experiments we found that egested biodeposits support rapid bacterial growth and uptake of dissolved P. These data, along with in situ measurements of phosphorus and carbon pools and hydrodynamics, were used to parameterize a simple 1-D model that we used to explore the effects of dreissenid nutrient egestion on water column plankton and nutrient dynamics. Results suggest that the ratio of dissolved: particulate P release by dreissenids has a strong influence on plankton concentrations. Removing dreissenids from the model affected the water column dissolved: particulate P ratio, but had little effect on the total P concentration.

Emma Abedrabo, Avie Krauss, Alex Robins, Jeneva Tomaszewski, Lindsey Willett, **Rebecca Bowen** and David Karpovich, Saginaw Valley State University. **Saginaw Bay Monitoring Consortium update: Tributary monitoring by SVSU's undergraduate student team.**

The Saginaw Bay Monitoring Consortium (SBMC) has established a tributary and open water monitoring framework for the Saginaw Bay Watershed. This coordinated, comprehensive, multi-year monitoring effort is unprecedented in the Saginaw Bay Watershed, and it will provide access to significant data for use by resource managers, scientists, and decision-makers to assist in

evaluating and restoring this very important ecosystem. Weekly monitoring for nutrient and sediment transport began in the summer of 2023 at 18 tributary sites by an undergraduate student team at Saginaw Valley State University (SVSU). Tributary monitoring locations were selected to represent coastal sub-watersheds of Saginaw Bay and major sub-watersheds of the Saginaw River, and each is co-located with a USGS gaging station. Complementary data are also being collected at 10 open water sites on Saginaw Bay by NOAA GLERL. This poster will provide an update on tributary monitoring activities, report highlights from first-year results, and describe how the SVSU undergraduate student team is coordinating the sampling schedule and meeting data quality requirements for this important initiative.

Jeff Bowman[1], Jennifer Baici[2], Thomas Burgess[2], Janet Greenhorn[1], Greg Melvin[1], Carrie Sadowski[1] and Meghan Ward[2], [1]Ontario Ministry of Natural Resources and Forestry, [2]Trent University.
Testing for causes of long-term muskrat declines in Great Lakes coastal wetlands.

Wetlands provide important ecosystem services, and consequently loss or degradation of wetlands can contribute to reduced human, animal, and environmental health. The muskrat (*Ondatra zibethicus*) is a culturally significant North American mammal that is considered a wetland engineer, leading to improved wetland function and increased biodiversity through the actions of foraging and house building. Anecdotal evidence suggests widespread muskrat declines however, so we have been conducting studies across Ontario to test for declines, and to evaluate potential causes and implications for wetland ecosystems. We have replicated historical surveys demonstrating declines of muskrat abundance of > 90% in sampled Great Lakes coastal wetlands and an overall low abundance across the region. We have conducted predator and disease studies. We have also shown that contemporary wetlands are dominated by invasive *Typha* x *glauca*, and subject to unnatural water-level regimes, both of which reduce interspersion between water and emergent vegetation, reducing muskrat habitat quality. Furthermore, we show that muskrat abundance is positively associated with wetland biodiversity. Consequently, it appears that invasive macrophytes and poorly managed water levels have reduced habitat quality for muskrats, which in turn has reduced the positive effects that muskrats have on biodiversity. To further evaluate these ideas, we are conducting experiments to test variables affecting muskrat abundance at both the wetland and whole lake scales. We discuss research findings, and larger One Health implications of reduced muskrat abundance.

Jess Bowser[1], Ryan Brown[2] and Jeena Koenig[1], [1]U.S. Fish and Wildlife Service, [2]University of Toledo. **Turning the page on data workflows: transitioning from paper to digital data collection.**

In 2018, the Grass Carp Response Program (GCRP) was established in Lake Erie to monitor and control the spread of Grass Carp (*Ctenopharyngodon Idella*). Since 2018, the program has grown from two field crews to 12, with a variety of data being collected across state and federal agencies and universities Data collection and management in a rapidly growing program can be challenging and there is never a one-size-fits all solution to data workflows, tools, or methods. Due to the complex nature and extent of data collection, sensitivity of results, and need for data accessibility across multiple agencies, a solution was needed to securely, and efficiently, manage program data. In 2020, the GCRP transitioned from paper data sheets to a centralized cloud-based database using ArcGIS Online* tools and applications. The GCRP uses multiple forms to simultaneously enter and access data from the field, laboratory, or office, across multiple states. Additionally, applications with agreed-upon standards have been developed to ensure quality control is completed promptly. This allows data managers to make quality data available in real-time, allowing for critical, rapid responses

when needed. The GCRP workflow is an example of how a large, rapidly growing program can transition from paper to digital data, reducing handling time, and enhancing data quality, while increasing communication, accessibility, and standardization.

Alexandra (Sasha) Bozimowski[1], Kurt Kowalski[1], Jared Militello[2] and Eric Dunton[3], [1]USGS Great Lakes Science Center, [2]USGS Great Lakes Science Center (Contractor), [3]USFWS Shiawassee National Wildlife Refuge. **Sonar data provide insights into fish passage and habitat use of restored coastal wetlands.**

Traditional monitoring of fish assemblages in restored wetlands (e.g., trap nets) is often contingent upon weather, time of day, water conditions, and personnel capacity. Sonar-based monitoring techniques can overcome these challenges by collecting continuous data with minimal oversight during all times of day, flow conditions, and water quality conditions. Post-restoration monitoring efforts at both the U.S. Fish and Wildlife Service Shiawassee National Wildlife Refuge (SNWR) in Saginaw, MI, and Ottawa National Wildlife Refuge in Oak Harbor, OH, utilized sonars stationed immediately adjacent to water control structures allowing fish passage between wetland habitats and parent water bodies. Sonars were deployed during ice-off periods to quantify the effects of restoring hydrologic connections to impounded coastal wetland units over multiple consecutive years. The resulting datasets were large and consisted of thousands of individual video data files (9675 and 2023 hours for SNWR and ONWR, respectively). Therefore, both semi-automated software and a machine learning model were developed and used to accelerate data processing and analysis. Over 70 TB of sonar data, a machine learning model capable of outputting bi-directional fish counts and individual fish length estimates, and a published semi-automated software ultimately yielded insight to millions of fish using the restored coastal wetlands. Sonar data revealed new insights into the abundance and patterns of fish accessing restored coastal wetland habitat**.**

Andrew Bramburger[1], Celine Siong[1] and **Andrew Budziak**[2], [1]Environment and Climate Change Canada, [2]8 String Media. **Under the Ice: A Story of Extreme Citizen Science, Collaboration, Exploration, and Discovery.**

Although most of the world's lakes are seasonally ice-covered, our understanding of limnological processes during the winter remains limited due to safety and logistical challenges associated with winter sampling. However, a recent resurgence of interest in winter limnology has inspired a flurry of activity in this area. While many investigators are beginning to characterize the function of the water column year-round, the sympagic habitat remains largely uninvestigated. Recent articles demonstrating extravagant ice-attached diatom biomass in Lake Erie and year-round reliance of marine trophic systems upon ice-associated primary production hint at the importance of this biota, but direct observations remain hampered by our inability to access the ice bottom. Here, we describe a novel twist on citizen science, wherein highly skilled volunteer ice-divers worked alongside researchers to collect samples from an otherwise inaccessible environment. We collaboratively designed a suite of novel equipment and techniques to isolate ice-associated biota from surrounding waters to retrieve undisturbed, uncontaminated samples. During February, 2024, we conducted complementary water column, sympagic, and benthic sampling in 2 bays in Lake of the Woods, comparing several parameters, including algal community composition, metagenomes, and fatty acid signatures. We hypothesize that sympagic communities are distinct from their mid-water column and benthic counterparts and anticipate that findings from this project will demonstrate the importance of the ice-associated community to year-round lake function, highlighting the increasingly imperiled nature of critical sympagic habitats.

Cory Brant[1], Ralph Tingley[1], Jonathan Doubek[2], Kevin Kapuscinski[2], Simon Freeman[2], Lindsie Egedy[1], Stacy Provo[1], Aabir Banerji[3] and Joel Hoffman[3], [1]U.S. Geological Survey Great Lakes Science Center, [2]Lake Superior State University, [3]U.S. Environmental Protection Agency.
Investigating fish recruitment constraints in the first year of life: A 2022 Lake Huron CSMI update.

Communities across the Great Lakes basin are growing increasingly concerned about a recruitment bottleneck for fishes (e.g., lake whitefish) that may be occurring within the first year of life. To further understand these constraints, the U.S. Geological Survey joined forces with multiple partners to sample age-0 fishes, their prey, and water chemistry across Lake Huron. Nearshore sampling consisted of four sites in southern Lake Huron and four sites in the North Channel. Sampling was conducted on the beach with hand-towed neuston nets and seines and at nearshore sites using small vessels towing paired bongo nets. Large vessels from several agencies were used to sample offshore sites across productivity gradients throughout the lake. Zooplankton tows or ponar grabs were collected within proximity to areas sampled for fishes. Preliminary results show only lake whitefish larvae were found at southern sites, while North Channel sites showed high coregonine diversity and generally higher densities. In both regions, fish densities were roughly an order of magnitude higher on beaches (1 m deep) than nearshore or offshore (1-15 m deep). Zooplankton densities, particularly of cladoceran taxa, were higher just after ice-off across sites, and higher for North Channel sites compared to southern sites. During summer, age-0 lake whitefish were captured mainly in Saginaw Bay by targeting the 16-18°C benthic thermal layer. Further analyses of these data will add to our understanding of this recruitment bottleneck.

Christopher Winslow[1], **Max Herzog**[2], **John F. Bratton**[3], **Barb Horn**[4] and **Mark Burrows**[5], [1]Ohio Sea Grant, [2]Cleveland Water Alliance, [3]LimnoTech, [4]Barb Horn, LLC, [5]International Joint Commission. **Development of a Great Lakes Community Science Guidebook.**

The International Joint Commission's Great Lakes Science Advisory Board Research Coordination Committee (SAB-RCC) recently completed Phase I of a Community Science study. The project reviewed existing community science efforts and illustrated that the most successful programs spend time up front to build relationships and collaborations and to conduct intentional planning. The diversity of current community science programs and products reflects both robustness and fragmentation. The Phase II project, which began in late 2023, will build on that foundation to produce an adaptable guidebook and a framework for a data-information repository on community science for the Great Lakes. This Guidebook will consist of (1) high-level outlines of best practice for both establishing and operating individual community science programs, and (2) how to both establish and operate networks of such programs. These products could fill data and information gaps for government agencies, and enhance public involvement, and ownership, in the management and protection of the Great Lakes ecosystem. They will also facilitate increased alignment of existing community science efforts and encourage more engagement in community science.

Flavia Breje and Andrea Kirkwood, Ontario Tech University. **Comparing the effects of different vegetation removal methods on macrophyte communities in the Kawartha Lakes.**

While macrophytes are critical to aquatic ecosystem health, they can become a nuisance in productive water bodies. The recent use of novel macrophyte removal methods, such as aquatic thrusters, has raised concern due to the lack of data on their efficacy and environmental impacts. As a collaborative effort with Kawartha Conservation, Parks Canada, and several universities, we conducted a lake-scale field study known as TAPER (Trent-Severn Aquatic Plant Experimental

Removal). A Before-After Control-Impact study design was employed to assess three vegetation-removal treatment types: Lake Rake, Motorized Weed-Cutter, and Oscillating Aquatic Thruster. Study sites were located at volunteer waterfront properties in lakes Canal and Scugog, which are part of the Trent-Severn Waterway National Historic Site. Percent cover and species presence-absence data was gathered biweekly from July until September 2023. Relative species abundance was obtained mid-study during the treatments and at the end of the field season. Preliminary results show that percent cover and species richness decreased after all treatments, except for the motorized weed-cutter in Canal Lake. Preliminary evaluation of plant cover changes also demonstrates varying effectiveness of the treatments based on the macrophyte species present. Through further analyses, this research will determine the impact on nearshore macrophyte communities and inform the public and management about maintaining healthy waterfront properties.

Alison Bressler and Jen Read, University of Michigan Water Center. **Developing the Western Lake Erie Basin Advisory Group in Michigan.**

Despite significant outreach by several Michigan agencies, water quality issues in the Lake Erie basin continue to be addressed by parallel and siloed communities of practice. These parallel efforts reinforce barriers to effective cross-sector networking and limit the efficacy of efforts to improve water quality and community well-being. Michigan's recent commitment to an active adaptive management approach under their Adaptive Management Plan to Reduce Phosphorus Loading to Lake Erie requires a multi-sector community advisory group. Therefore, in 2023 the University of Michigan Water Center team worked with representatives from Michigan's Quality of Life Agencies: MDARD, EGLE, and DNR to identify and recruit an initial Advisory Group designed to bring diverse perspectives together to inform the implementation of Michigan's Domestic Action Plan. The Water Center recruited over 60 Advisory Group members, each a community leader, which resulted in a network of networks of those interested in Western Lake Erie Basin water quality. Advisory Group members are directly or indirectly involved in managing point or nonpoint phosphorus sources, are affected by excess nutrients in water, or are environmental advocates. This presentation will discuss the process of forming the Advisory Group and facilitating engagement between and among Michigan's Quality of Life Agencies and Advisory Group members.

Colin Brooks[1, 2] and Amy Marcarelli[1, 3], [1]Michigan Technological University, [2]Michigan Tech Research Institute, [3]Biological Sciences Department. **Using drone imagery to quantify changes in Eurasian watermilfoil extent due to different treatment methods.**

Remote sensing data such as aerial and satellite imagery can be a useful assessment tool for quantitative assessment of floating and emergent plants, however, there has previously been limited success for submerged aquatic vegetation (SAV) identification. For this research, we visited sites in the Les Cheneaux Islands of northwestern Lake Huron and the Keweenaw Waterway near Lake Superior to collect multispectral drone and plant identification data. Our work has demonstrated that drone-enabled mapping of SAV vegetation using multispectral sensors can produce quantitative information on the change in Eurasian watermilfoil (EWM) extent in response to three types of treatment: mechanical harvesting, diver-assisted suction harvesting (DASH), and fungal treatment. Our goal was to understand if and how quantitative results could be created using drone-enabled sensing that would reflect the visible effects of different treatment methods, supported by field measurements. Using object-based image analysis of the drone data, we were able to quantify a 63% reduction in EWM extent at a mechanical harvesting site (with significant fragmentation issues), a 47% reduction at a fungal treatment site, and an 89% reduction at a DASH treatment site. Drone-

enabled multispectral monitoring of SAV can help quantitatively monitor the effects of different treatment methods.

Katelyn Brown[1], Katelyn Barker[1], Ryan Wagner[1], Christopher Ward[1], Lewis Sitoki[2], James Njiru[3], Reuben Omondi[4], James Achiya[3], Albert Getabu[4], R. Michael McKay[5], George Bullerjahn[1] and NSF-IRES Lake Victoria Research Consortium[6], [1]Bowling Green State University, [2]Technical University of Kenya, [3]Kenya Marine and Fisheries Research Institute, [4]Kisii University, [5]Great Lakes Institute for Environmental Research, [6]www.agl-acare.org/bgsu-2022. **Bacterial community and cyanotoxin gene distribution of the Winam Gulf, Lake Victoria, Kenya.**

The Winam Gulf (Lake Victoria, Kenya) is frequently impaired by cyanobacterial harmful algal blooms (cHABs) due to inadequate wastewater treatment and excess agricultural nutrient input. Our aim of this project is to identify potential toxin-producing cyanobacteria using molecular approaches. The Gulf was sampled over two successive summer seasons, and 16S and 18S ribosomal RNA gene sequencing was performed. Additionally, key genes involved in production of cyanotoxins were examined by quantitative PCR. On the eastern side of the Gulf, samples exhibited elevated *cyrA* abundances, indicating genetic capability of cylindrospermopsin synthesis. Indeed, near the Nyando River mouth in 2022, *cyrA* exceeded 10 million copies L^{-1} where there were more than 6,000 *Cylindrospermopsis* spp. cells mL^{-1}. In contrast, the southwestern region had elevated *mcyE* gene (microcystin synthesis) detections near Homa Bay where a small community of *Microcystis* spp. was observed. In this location, a strain of *Microcystis panniformis* was isolated and the whole genome was sequenced. This resulted in a 4.26 Mbp genome containing a complete *mcy* operon that correlates with frequent detections of microcystins in the Gulf. These findings show that within a relatively small embayment, composition and toxin synthesis potential of cHABs can vary dramatically. This underscores the need for multifaceted management approaches and frequent cyanotoxin monitoring to reduce human health impacts.

Sabrina Brown, Katelyn Smith and Hallie Webb, Defiance College. **The Defiance Research Alliance: What is it and where are we going?**

The Defiance Research Alliance is a partnership between Defiance College, the City of Defiance, and Defiance County schools to address water quality issues in the Upper Maumee Watershed. This collaboration harnesses student excellence and leverages community research and development assets to conduct applied water quality research. This presentation will guide the audience through the progress this new partnership in its first year and a half. Two ongoing research projects will be highlighted. First, an undergraduate research project evaluated the summertime phytoplankton community on the Maumee River. By tracking chlorophyll a, phycocyanin, and diatom counts, as well as inorganic variables such as nitrate, ammonia, pH, specific conductivity, turbidity, and water temperature, an in depth profile of the rapid changes within the Maumee River phytoplankton community will be established. The purpose of this project was to determine the range of conditions that support specific phytoplankton blooms at three locations along the Upper Maumee River. Second, a collaborative watershed monitoring project in the Upper Maumee Watershed that focuses on stream health through analyzing chemical parameters and diatom assemblages. By comparing the numerical data from water sampling and diatom assemblages, the city of Defiance can learn more about the quality of the Maumee River and better understand the surrounding environment, the nutrients and amount of sediment in the water.

Taylor Brown[1], Lars Rudstam[1], Suresh Sethi[2], Jason Smith[3], Christopher Hessell[4], Erik Olsen[4], Ji He[5], Jory Jonas[5], Benjamin Rook[5], Joshua Blankenheim[6], Sarah Beech[7], Erin Dunlop[8], Stephen James[7], Steven Pothoven[9], Zachary Amidon[10], John Sweka[11], Dray Carl[12], Scott Hansen[12], David Bunnell[13], Brian Weidel[13] and Andrew Honsey[13], [1]Cornell University, [2]Brooklyn College, [3]Bay Mills Indian Community, [4]Grand Traverse Band of Ottawa and Chippewa Indians, [5]Michigan Department of Natural Resources, [6]Minnesota Department of Natural Resources, [7]Ontario Ministry of Natural Resources and Forestry, [8]Ontario Ministry of Natural Resources and Forestry, [9]National Oceanic and Atmospheric Administration, [10]University of Toledo, [11]U.S. Fish and Wildlife Service, [12]Wisconsin Department of Natural Resources, [13]U.S. Geological Survey. **Reconstructing half a century of lake whitefish and cisco recruitment dynamics across the Great Lakes.**

Lake whitefish (*Coregonus clupeaformis*) and cisco (*C. artedi*) are socioecologically important fishes across the Laurentian Great Lakes; however, many populations of both species have experienced sporadic or declining recruitment in recent decades. Generating comparable year-class strength (YCS) indices among lakes and species shows strong promise for improving understanding of the processes driving recruitment variability across biophysical gradients and life-histories. We integrated 38 long-term surveys of lake whitefish and cisco catch and age data across each of the Great Lakes and Lake Simcoe. This combined time-series spans 1960-2019 and represents the most comprehensive dataset compiled for analyzing Great Lakes coregonine recruitment to date. We estimated lake whitefish and cisco YCS in each lake using longitudinal mixed effects regressions of relative cohort abundance through time. We subsequently quantified spatiotemporal synchrony in YCS among lakes using correlation and dynamic factor analyses. Generally, lake whitefish YCS was positively synchronized among lakes and has declined from a period of elevated YCS during the 1980s-1990s, whereas cisco YCS was sporadic, varied around the long-term mean relative to each lake, and was largely asynchronous among lakes. Ongoing work is using these standardized YCS estimates to investigate underlying biophysical drivers of cross-species, cross-basin recruitment variability.

Shelby Brunner, Katie Rousseau, Tim Kearns, Rebecca Pearson and Jennifer Boehme, Great Lakes Observing System. **Where are observations most valuable? A conversation starter.**

The Great Lakes Observing System (GLOS) is a non-profit focused on observing, data aggregation, and information sharing for the Great Lakes region. GLOS is currently involved in a number of science initiatives that would benefit from community dialogue, including two new proposals, the IJC Science Collaborative, and the National HAB Observation Network. GLOS recently engaged the Common Mission Project to identify underserved communities challenged with climate vulnerabilities, aiming to best place suitable observation assets like buoys to collect data that will inform management decisions. Recently, two 5-year proposals were submitted to our major funding source, the Integrated Ocean Observing System, focused on expanding work related to improved coastal and climate resiliency, particularly for underserved communities. The focus areas are year-round observations, water levels/waves, and ecosystems, all towards improved coastal resiliency for our region. Funding will be awarded in the second half of 2024 and part of our proposed work is to engage with members of the community to identify areas of highest need and how to improve the tools available to localities. We anticipate this presentation to be an opportunity to hear from diverse members of the Great Lakes research community on observing needs for their work, and particularly those that would benefit underserved communities. This input will help with future investment decision making, allowing us to more effectively implement observing systems around the basin and engage potential new partners.

Sophie Bryden, **Cassie McHugh**, **Willy Pevec**, **Alexis Rolling** and **Ian Stone**, University of Michigan. **Great Lakes Marine Protected Areas: Designating and Managing for Success.**

The United States (U.S.) and Canada have each set goals to conserve 30% of lands and waters by 2030 (i.e., 30x30 goals). Marine protected areas (MPAs) serve as one method for the United States and Canada to safeguard Great Lakes ecosystems and resources and achieve those 30x30 conservation goals. However, the U.S. and Canada employ different approaches to designating, regulating, and managing MPAs in the Great Lakes, leading to potential discrepancies in social and conservation outcomes. As 2030 approaches, we investigate how the National Oceanic and Atmospheric Administration (NOAA) and Parks Canada might best leverage their MPA programs to meet 30x30 conservation targets, optimize conservation effectiveness, enhance transnational collaboration, involve local stakeholders, and incorporate Indigenous peoples and First Nations in governance. We use a multi-pronged approach consisting of a literature review, geospatial analysis, and semi-structured interviews to evaluate NOAA's and Parks Canada's Great Lakes MPA programs. Our analysis concentrates on Lake Superior as a case study, and we extrapolate applicable lessons from that case study to the broader Laurentian Great Lakes region. Based on our analysis, we discuss the value of MPAs for achieving Great Lakes conservation goals and provide recommendations for how NOAA and Parks Canada might enhance their MPA governance processes and collaboration.

Mary-Claire Buell[1], **David Ruffo**[2], **Jessica Zadori**[2] and **Mathew Stone**[2], [1]Trent University, [2]Michipicoten First Nation. **Community-led contaminants surveillance: Michipicoten biomonitoring studies.**

This presentation will explore the importance of community-led contaminants surveillance programs, by sharing the ongoing biomonitoring studies Michipicoten First Nation has been conducting to understand and monitor contaminant loads in fish from their Territory. Currently government provided fish consumption guides are seldom used, yet there is concern that some fish within MFN Territory may be contaminated. By engaging community harvesters, and youth, MFN Lands & Environmental Stewardship office is changing the way fish contaminants monitoring programs are typically done. Our project has prioritized creating opportunities to be on the land and trust building through community engagement. We have developed local fish consumption guides and are continuing this work through annual updates. Through sharing our approach we hope that others will see the importance of co-led and co-designed projects and the importance of community engagement through the entire research project.

George Bullerjahn, Bowling Green State University. **US/Canada/Kenya Collaborative research on HABs and contaminants on Lake Victoria.**

Through a partnership funded by the National Science Foundation (IRES award 1953468), teams of four North American faculty and 7-9 graduate students worked with similarly-sized Kenyan cohorts of faculty and students, studying the composition of HABs and microbial communities in Lake Victoria. An additional successful project assess levels of mercury in Nile Perch harvested from the Lake. The project focused on the Winam Gulf, an embayment of Lake Victoria prone to blooms of *Dolichospermum* and *Microcystis*. Two multi-day cruises during June/July 2022 and May/June 2023 revealed the presence of additional HAB threats in the form of *Raphidiosis* blooms that had the capacity to produce cylindrospermopsin. A final short followup cruise is scheduled for early 2024 to verify these findings. This presentation will focus on both the results of our surveys, as well as an overview of how we developed our effective partnership between US/Canadian universities (Bowling Green, Windsor and home institutions of the graduate students), and Kenyan institutions

(Kenyan Marine and Fisheries Research Institute, Kisii University and Technical University of Kenya).

Ryan Wagner, **George Bullerjahn**, Chris Ward, Michelle Neudeck, Alexis Heath, Katie Barker, Kate Brown and Seth Buchholz, Great Lakes Center for Fresh Waters and Human Health 2 Center for Great Lakes and Watershed Studies, Department of Biological Sciences, Bowling Green State University, Bowling Green OH 43043, USA. **The recent disappearance of a Planktothrix bloom: characterization of a regime shift in Sandusky Bay.**

Sandusky Bay is the drowned mouth of the Sandusky River in the southwestern portion of Lake Erie. The bay is a popular recreation location and a regional source for drinking water. Like the western basin of Lake Erie, Sandusky Bay is known for being host to summer cyanobacterial harmful algal blooms year after year, fueled by runoff from the predominantly agricultural watershed and internal loading of legacy nutrients (primarily phosphorus). Since at least 2003, Sandusky Bay has harbored a microcystin-producing bloom of *Planktothrix agardhii,* a species of filamentous cyanobacteria that thrives in low light conditions. Long-term sampling (2003 - 2018) of Sandusky Bay revealed regular *Planktothrix*-dominated bloom during the summer months, but in recent years (2019-2022), 16S rRNA gene community profiling revealed that *Planktothrix* has largely disappeared. From 2017-2022, microcystin toxins decreased well below WHO guidelines, yet there were no statistically different shifts in water temperature. With the exception of the high bloom of *Planktothrix* in 2018, there was no statistical difference in chlorophyll during all other years. Concurrent with disappearance of *Planktothrix*, *Cyanobium* species have become the dominant cyanobacterial group. The appearance of other potential toxigenic genera may motivate monitoring of new toxins of concern in Sandusky Bay. Here we document the regime shift in the cyanobacterial community and hypothesize that the decline in the *Planktothrix* bloom was linked to the removal of an upstream dam on the Sandusky River.

Andrew Bumps[1, 2], Emily Tryc[2], Kevin Pangle[2] and Wiline Pangle[2], [1]University of Dayton, [2]Institute for Great Lakes Research Central Michigan University. **Round goby male reproductive tactics: connections to environmental factors and impacts on behavior.**

Round gobies (*Neogobius melanostomus*) are small, benthic fish native to the Black and Caspian Seas that are now invasive around Europe and the Great Lakes. Male gobies exhibit alternative reproductive tactics, in which guarders invest energy into body size and nest protection, while sneakers are smaller and invest in sperm production to sneak into nests to fertilize eggs. Our study investigated the influence of environmental factors on the ratio of sneaker to guarder males and the influence of this ratio on aggressive and exploratory behaviors. We used GoPro footage, minnow trap collections, and environmental observations from 4 nearshore sites around Beaver Island, Michigan. Reproductive tactics of individual male specimens were determined using gonadosomatic index and length. Our results show that interstitial space, wave action, weather, density, and temperature appear to impact the ratio of sneaker to guarder males. Based on video footage, the percentage of guarders and aggression both increased with density, indicating possible correlation. In addition, smaller gobies were more exploratory than larger ones, indicating that male alternative reproductive tactics may strongly influence goby behavior. Our study demonstrates a highly variable, environmentally-driven structure of round goby populations, which in turn likely influences their ecological role in these nearshore ecosystems.

Lyubov Burlakova[1], Alexander Karatayev[1], Jill Scharold[2], Olesia Makhutova[1], Susan Daniel[1] and Knut Mehler[1], [1]SUNY Buffalo State, [2]US EPA. **Decadal changes in Lake Superior benthic community.**

Lake Superior has been considered relatively undisturbed by anthropogenic impacts due to its large size and limited watershed development, but recent studies revealed a rapid warming and increase in primary production. To assess changes in benthic community of Lake Superior we compiled available data into three datasets: data from lake-wide surveys (1973, 2005, 2006, 2011, 2016, 2022); 27 historical nearshore stations (1994, 2000, 2003, 2016, 2022); and 11 U.S. EPA Great Lakes Biological Monitoring Program (GLBMP) long-term monitoring stations (1999-2022). Lake-wide, we found an increase in density of most taxonomic groups in the 2000s compared to the 1970s and most recent decade. At the 27 historical nearshore stations, the density of *Diporeia* in 2022 declined significantly by 70% compared to 1994 and was the lowest of all previous surveys. Nevertheless, the current *Diporeia* abundance is still almost twice as high at comparable depths and locations than in 1973. Mean densities of Oligochaeta and Sphaeriidae declined by 50% compared to 1994, but no changes were found in Chironomidae. In contrast, no temporal trends in densities of these taxa were found at the 11 GLBMP stations located at >50 m depths, indicating that the changes might have occurred mainly in the nearshore zone. Further monitoring is essential to determine whether the current decline in *Diporeia* and other major groups in Lake Superior indicate a long-term trend in the nearshore benthos.

Lucinda Busselle[1], W. Robert Midden[1] and Lauren Kinsman-Costello[2], [1]Bowling Green State University, [2]Kent State University. **Effects of Some Flow-In/No-Flow-Out Wetland Pools on Phosphorous and Nitrogen Export.**

Wetlands have been shown to reduce the phosphorus (P) and nitrogen (N) export to the watershed in some circumstances and are proposed as a resource for mitigating the adverse environmental effects of these pollutants. We are reporting findings of the analysis of soil as a part of the evaluation of the effects on P and N transport of five flow-in/no-flow-out pools (FINFO) pools in a wetlands project consisting of a total of 43 pools. The other thirty-eight pools are Geographically Isolated Wetlands (GIWs), which have no discrete water inflow or outflow. The FINFO pools receive outflow from 8-inch diameter pipes that deliver water drained from land outside the project area. These pools have no discrete outflows and are designed to receive and hold the water until it evaporates or permeates into the soil. To estimate the effects of the FINFO pools on P and N transport, soil samples from these pools were analyzed for total P and N; Mehlich-3 P, iron, and aluminum; soil P storage capacity (SPSC); water extractable P, nitrate, ammonium; pH; and electrical conductivity and compared to that of soil taken from upland areas near those pools. Results were also compared to some GIWs pools in the area. These results were analyzed to estimate the differences in effects of the FINFO pools relative to GIWs pools on P and N export to the watershed.

Danyka Byrnes[1], Kimberly Van Meter[2] and Nandita Basu[1, 3], [1]Department of Civil and Environmental Engineering, University of Waterloo, [2]Department of Geography, The Pennsylvania State University, [3]Department of Earth and Environmental Sciences, University of Waterloo. **Nitrogen memoryscapes: Patterns in nitrogen inputs and riverine export across the continental United States.**

Nitrogen pollution has severely impacted our inland and coastal waters, contributing to algal blooms, eutrophication, and contamination of drinking water. To date, most research focused on the linear relationship between nitrogen inputs and stream loads, contributing to the implicit assumption

that reduced nitrogen inputs would decrease loads. Despite concerted efforts, widespread water quality improvements remain, in many cases, elusive. Our work aims to understand the underlying mechanisms that drive changes in nitrogen loads in various watershed contexts, revealing that the factors driving loads can differ from those influencing changes in nitrogen loads, thereby challenging the conventional linear relationship. Here, we use a multi-decadal (1990-2017) timeseries of nitrogen inputs and stream loads for over 400 watersheds across the contiguous US. We find that watershed behavior falls into four typologies based on their nitrogen inputs and nitrogen loads trends: Input-driven, Transitioning, Bright Spots, and Delayed-response. Agricultural 'input-driven' watersheds' loads are driven by the current year's agricultural inputs in highly tile-drained landscapes. Highly urban 'bright spots' watersheds' loads are likely driven in large part by effective management of human waste. Lastly, we find that Transitioning and Delayed-response watersheds, which have nitrogen surplus and nitrogen load trends in opposite directions, indicate the influence of legacy nitrogen. Accounting for the unique characteristics and histories of each watershed can help develop more effective strategies for managing watersheds and achieving desired environmental outcomes.

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David Cannon[1], Ayumi Fujisaki-Manome[1], Jia` Wang[2], Abby Hutson[1], James Kessler[2], Hongyan Zhang[3], Ed Rutherford[2] and Doran Mason[2], [1]University of Michigan, CIGLR, [2]NOAA GLERL, [3]Eureka Aquatic Research, LLC. **Simulating Projected Climate Warming in the Laurentian Great Lakes Using FVCOM+CICE.**

Over the last century, the Laurentian Great Lakes have undergone significant changes, with increased surface and subsurface temperatures and decreased ice cover durations and concentrations. While observed changes in surface conditions have received considerable research interest, changes in subsurface conditions, including stratification and vertical mixing, remain largely unexplored, especially in the context of projected warming scenarios. In this study, we investigate projected changes in thermal structure and ice cover in the Laurentian Great Lakes using a coupled hydrodynamic-ice model (FVCOM+CICE), with continuous simulations over the historical (1979 - 2014) and future (2015 - 2100) periods. The model is forced using global climate models (CMIP6: GFDL-ESM4, MIROC6, ECEarth3) under three shared socioeconomic pathways (SSP1-2.6, SSP2-4.5, SSP5-8.5), with model outputs ensembled to produce realistic changes in lake climatology. Future climate projections suggest that warming trends will continue into the next century, with a 50 - 80% decrease in annual maximum ice cover under all scenarios by 2100. The most extreme warming scenario (SSP5-8.5) is expected to lead to severe increases (+3 - 8 ℃) in summer surface temperatures by end-of-century, with commensurate increases (decreases) in the strength of summer (winter) stratification. Analysis suggests that warming will result in mixing regime shifts (dimictic to warm monomictic) in Lakes Michigan, Huron, and Ontario, resulting in dramatic changes in food-web dynamics and biogeochemical cycles in each lake.

Stuart Carlton[1], Tim Campbell[2], Katherine O'Reilly[3], Isabelle Paulsen[4] and Katherine Zipp[5], [1]Coastal & Great Lakes Social Science Lab/Illinois-Indiana Sea Grant, Department of Forestry & Natural Resources, Purdue University, [2]Wisconsin Sea Grant, [3]Illinois-Indiana Sea Grant & University of Illinois Prairie Research Institute, [4]Coastal & Great Lakes Social Science Lab, Department of Forestry & Natural Resources, Purdue University, [5]Department of Agricultural Economics, Sociology and Education, Penn State University. **Clean, Drain, Why? Aquatic invasive species prevention behavior among Great Lakes boaters.**

Aquatic invasive species (AIS) have transformed the Great Lakes socio-ecosystem. While AIS can be introduced and spread via several pathways, one that has received considerable research and outreach focus is recreational boating. Boaters may inadvertently move AIS between waterbodies through fouled boating or fishing gear, residual water in boating compartments, and/ or the release of bait. To minimize the spread of AIS, outreach efforts typically request boaters to take several preventative actions, collectively known as "Clean, Drain, Dry." Despite the significant resources invested in outreach, evaluations of whether boaters are performing these actions - and why they do or do not - are lacking. In this talk, we present the results of a survey of boaters in Great Lakes states, examine the extent to which boaters report performing preventative behaviors, and explore what attitudes are driving (in)action. We also pull from the grey literature to contextualize boater behavior over time. Our results provide key insights to help researchers, policymakers, and outreach professionals better understand recreational boating as a pathway for AIS and design effective outreach techniques.

Hunter Carrick[1], Erin Bagosy[1], Dominic Wells[1], Casey Godwin[2], Andrew Camilleri[2], Reagan Errera[3] and Henry Vanderploeg[3], [1]Department of Biology, Central Michigan University, [2]Cooperative Institute for Great Lakes Research, [3]NOAA Great Lakes Environmental Research Lab.
Plankton C and P uptake in pre, during, and post cyanobacterial blooms in western Lake Erie.

In western Lake Erie, spring watershed loadings (March-April) appear to deliver nutrients that promote the harmful algal blooms (HAB) in the following summer months (July-August). We ascertained if specific components of the assemblage consistently sequestered nutrients using direct measurements of C and P uptake by plankton. We measured seasonal phytoplankton biomass and nutrient uptake rates (C and P) at 4 stations in 2022-23 during major temporal periods in western Lake Erie. These included pre (April), during (July-August), and post (September to October) HAB events. Phytoplankton abundance was determined from microscopic analysis of water samples. Size specific uptake of radio-labelled tracers of C and P was measured using the 14C and 32P enclosure experiments. During the pre-bloom, C and P uptake was performed by nanoplankton (> 60% of total) when phytoplankton biomass was comparatively low and dominated by centric diatoms among the 4 stations (chlorophyll, 8.8 +/- 3.6). During the bloom, uptake was dominated by microplankton > 20 um in size (60% of total), when biomass was greatest, and cyanobacteria were abundant (chlorophyll, 109.3 +/- 89.5). During the post-bloom, microplankton uptake remained dominant (60-80% of total), even though biomass of a mixed assemblage declined at all 4 sites (chlorophyll, 12.5 +/- 5.3). These findings suggest that nutrients loaded in the spring were evidentially sequestered (and retained) by cyanobacteria throughout the July to September growing period.

Mbumba Chalira, Malawi University of Science and Technology. **Assessing the Effectiveness of a Remotely Operated Underwater Vehicle as a Novel Tool for Monitoring Freshwater Fish Biodiversity in Lake Malawi.**

Lake Malawi is home to unique fish populations facing escalating threats, necessitating urgent conservation measures. Community-based fisheries co-management, led by local entities, is crucial for safeguarding ecosystems, with fish sanctuaries as integral components. This study assesses the suitability of Remotely Operated Underwater Vehicles (ROVs) for monitoring fish biodiversity in Lake Malawi. Evaluating ROV effectiveness in capturing variations in species diversity and abundance along benthic depth gradients, comparing ROVs with SCUBA diving methods in determining fish assemblage composition, and exploring computer vision applications using

YOLOv5 with ROV video data, focused on Thumbi West in Lake Malawi National Park. ROV surveys showed no significant variations in species diversity and abundance along benthic depth gradients ($p > 0.05$). However, site 2, with a complex habitat structure, exhibited significant variations in assemblage composition ($p < 0.05$). Comparison with traditional diving methods highlighted substantial disparities in fish assemblage composition (ANOSIM, $R > 0.05$). YOLOv5 achieved a mean Average Precision of 0.611, indicating effective computer vision applications. The study demonstrates that ROVs are more effective in complex habitats, offering meaningful biodiversity insights. ROVs prove effective for biodiversity analysis compared to SCUBA divers. Lastly, ROV data can train computer vision models, making ROVs valuable tools for biodiversity monitoring in Lake Malawi.

Rosen Chang, Aisha Javed and George Arhonditsis, University of Toronto. **SWAT modelling of the Nitrogen Cycle in the Bay of Quinte Watersheds.**

The Bay of Quinte is a long narrow bay located on the northeastern shore of Lake Ontario. This popular tourist destination endured a long history of eutrophication characterized by the presence of algal blooms due to high nutrient export from upstream watersheds. Past modelling work has attempted to investigate the mechanisms and drivers of long-term phosphorus export in the area. By focusing on phosphorus export, past work has overlooked the role of nitrogen, which may play an important role in the proliferation and production of harmful algal blooms. This study aims to bridge this knowledge gap by characterizing the nitrogen cycle using a pre-existing hydrological, sediment and phosphorus model for the Soil and Water Assessment Tool (SWAT), of the Napanee River and Wilton Creek watersheds of the Bay of Quinte. SWAT was calibrated for 2002-2015 and validated for 2016-2018 using observed daily streamflow and Load ESTimator (LOADEST) regression model outputs for the observed daily nitrogen (TN, NO2, NO3, NH4) loads. The LOADEST model was used to interpolate the loads and projected an increase only in NH4 out of the different nitrogen forms. The preliminary results for the SWAT application will include the assessment of areas and times of high nitrogen export for the effectiveness of different cover crops and riparian buffers as best management practices in mitigating nitrogen export for improved water quality conditions of the Bay.

Wenyu Long[1], Keira Harshaw[2], Yunfeng Wang[3], Qianqian Xiang[1], Hugh MacIsaac[2], Minmin Niu[1], Qiwen Xi[3] and **Xuexiu Chang**[2], [1]Yunnan Collaborative Innovation Center for Plateau Lake Ecology and Environmental Health, College of Agronomy and Life Sciences, Kunming University, [2]Great Lakes Institute for Environmental Research, University of Windsor, [3]Fishery Technology Extension Station of Yunnan. **A New Dominant *Microcystis* in Dianchi Lake (China) Disrupts Food Intake in Fish by Regulating Neurotransmitters and Hormones.**

Cyanobacterial harmful algal blooms (cHABs) are pervasive sources of stress resulting in neurotoxicity for fish. *Microcystis wesenbergii* has become a new dominant bloom-forming species of cyanobacteria found in many freshwater lakes, including Dianchi Lake (China). However, unlike its more well-known counterpart *M. aeruginosa*, the effects of dense *M. wesenbergii* blooms are seldom studied. The disturbance of appetite and feeding behaviour can have downstream effects on the growth of teleost fish, posing a significant challenge to aquaculture and conservation efforts. This study examined the effects of *M. wesenbergii* blooms on the food intake of *Acrossocheilus yunnanensis*, a native cyprinid in southern China. This fish has disappeared in Dianchi Lake, and its reintroduction might be negatively affected by the presence of this new dominant *Microcystis* species. We co-cultured juvenile *A. yunnanensis* with *M. wesenbergii* at initial densities ranging from 5×10^4 to 1×10^6 cells/mL and monitored feeding behaviours, and protein levels of neurotransmitters and hormones. High-

density *M. wesenbergii* cultures increased the feeding rate of co-cultured fish, elevating concentrations of appetite-stimulating signalling molecules (Agouti-related protein and γ-aminobutyric acid), while decreasing inhibitory ones (leptin). These changes coincided with histopathological alterations and reduced somatic indices in brain and intestinal tissues. Given this potential for detrimental effects and dysregulation of food intake, further studies are necessary to determine the impacts of chronic exposure of *M. wesenbergii* in fish.

Xuexiu Chang[1], Runbing Xu[2], Yu Qian[2], Doug Haffner[3], Lei Zhang[3], Hucai Zhang[2], Michael Siu[4], Michael McKay[3], Zhiming Zhang[2] and Hugh MacIsaac[3], [1]Yunnan Collaborative Innovation Center for Plateau Lake Ecology and Environmental Health, College of Agronomy and Life Sciences, Kunming University, [2]School of Ecology and Environmental Sciences, Yunnan University, [3]Great Lakes Institute for Environmental Research, University of Windsor, [4]University of Windsor. **From Plateau Lakes to the Laurentian Great Lakes: collaborations between Windsor (Canada) and Yunnan (China).**

Shared challenges and initiatives in the Plateau Lakes and the Laurentian Great Lakes led to collaborations between universities in Yunnan and Windsor, including topics of harmful algal blooms, invasive species, multiple stressors and climate change. Beginning in 2014 with memoranda on "Sino-Canadian Plateau Lakes Alliance" and "International Joint Laboratory on Plateau Lakes Research", the "Sino-Canadian Plateau Lakes Research Centers" were established between the University of Windsor and universities from Yunnan Province, China. After the first Sino-Canadian Workshop on Plateau Lakes Research in Kunming (2015), the bi-national team was strengthened by faculty and student exchanges, joint courses, workshops, co-PI funded grants/programs (including participation in the 2019 Lake Erie HABs Grab) and numerous co-authored papers. Despite challenges such as the COVID-19 pandemic, collaborations between Canadian and Chinese partners on lake research continue to flourish as evidenced by recent approval by the Education Ministry of the Yunnan Provincial Government of the International Joint Innovation Team for Yunnan Plateau Lakes and Laurentian Great Lakes, thus paving the way for continued Sino-Canadian cooperation toward a better understanding of large lakes science, including enhanced safeguarding of water quality and biodiversity. Recently, Kunming University, Yunnan University and University of Windsor are jointly planning a Workshop of Horizon Scan on freshwater Harmful Algae Blooms (HABs) in July 2024, to identify the most important questions about the freshwater HABs to be addressed.

Shagun Chaudhary[1], Pradeep Goel[2], Sabrina Jivani[1], Dillon Hendrik Vyn[1] and Clare Robinson[1], [1]Department of Civil and Environmental Engineering, Spencer Engineering Building, Western University, [2]Water Monitoring Section, Environmental Monitoring and Reporting Branch, Ministry of the Environment. **Characterizing First Flush Behavior in Urban Subwatersheds Located in Continental Climates.**

First flush phenomena, which refers to the initial volume of event runoff containing the highest pollutant concentrations, is an important consideration for quantifying stormwater pollutant loads and improving implementation of stormwater management practices. Many methods are available for defining whether a first flush occurs with mass-based first flush definitions commonly applied. Prior studies focused on quantifying first flush are mostly based in temperate climates. It is unclear whether existing definitions are suitable for continental climates due to differences including cold climate factors and altered precipitation characteristics. The study objective is to examine the influence of rainfall and watershed characteristics on first flush behavior of pollutants in urban and mixed-urban subwatersheds located in continental climates. Time-series of event rainfall, runoff and

TSS, TP and SRP concentrations were obtained from six subwatersheds across Canada located in London, Hamilton and Saskatoon. Data were analyzed using mass-based first flush definitions with results indicating occurrence of first flush varied between pollutants, between locations, and as a function of rainfall depth and runoff volume. Results indicate that it may not be appropriate to adopt universal first flush definitions across all climates. Finally, an alternative method based on quantifying initial and background pollutant runoff concentrations via non-parametric statistics was used to assess first flush. This approach found a significant reduction in pollutant concentration after a runoff depth of 2 - 4 mm.

Emily Jepyegon Chemoiwa, E Njenga, R Abila, A Macdonald and J Lamb, University of Eldoret.
Assessing Diversity of Labeobarbus altianalis (Boulenger 1900) Populations in Lake Victoria Watershed Using MtDNA for Fisheries Management and Conservation.

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.

Stacey Cherwaty-Pergentile, Nancy Stadler-Salt, Sean Backus and Luca Cargnelli, Canada Water Agency.
Engaging Great Lakes residents through community-based Science: A Case Study of Recreational Water Quality Monitoring.

The public plays an essential role in restoring and protecting Great Lakes water quality and ecosystem health, and community-based science can significantly impact research and science and increase the value of community-based science in decision-making within the Great Lakes. With support from Environment and Climate Change Canada, Swim Drink Fish established recreational water quality monitoring hubs in six communities along the shores of the Great Lakes, increasing the proportion of Great Lakes waters monitored and creating measurable environmental protection goals. It guided over 120,000 recreational water users in making informed decisions about water quality and recreational use. The hubs worked with over 1,700 community members to collect 5,800 water quality samples. The project connected with community members to increase and foster water literacy in creating water stewards through this hands-on community science program. Resources and tools were developed to help community groups across the Great Lakes start, maintain, and grow their recreational community-based water monitoring hubs. Data collected by community-based science initiatives are being translated and incorporated into research projects, science publications, reporting, and indicators, in addition to playing an essential educational role in communities. Through the Great Lakes Freshwater Ecosystem Initiative, ECCC will continue to

support the growth of community-based science, focusing on efforts to address priority science issues and increase the value of community-based science in decision-making and informing science needs for the Great Lakes.

Aisha Chiandet[1], Sarah Playfoot[2] and Nolan Pearce[2], [1]Severn Sound Environmental Association, [2]Trent University. **Beyond delisting in Severn Sound - How do things look 20 years after the party is over?**

The Severn Sound Remedial Action Plan started out as a federal-provincial initiative to address eutrophication and habitat loss. Severn Sound, a complex of bays and inlets in south-eastern Georgian Bay, became the second Great Lakes Area of Concern to delist when the community of small urban centers and rural townships became fully committed to the restoration of Severn Sound as a "toxic hot-spot" on the Great Lakes. Following the delisting of Severn Sound, creative local partnership agreements and financing were established to continue long-term monitoring and implementation of remedial actions, and to meet emerging environmental challenges such as climate change, invasive species, and land use alteration. Various environmental monitoring was also continued by other government agencies. This presentation will provide an overview of the state of Severn Sound 20 years post delisting using a wide-ranging suite of indicators related to tributary, sediment and open water quality and lower food web, fish and wildlife populations, habitat and contaminant load, land cover, and beaches among others. These indicators were originally reported on in the Stage 3 delisting report and many have not been comprehensively updated since. Included is Traditional Oral Knowledge contributed by Indigenous community members, which has not been incorporated in past reporting efforts. Also discussed are recommendations for future monitoring and restoration efforts, along with some of the challenges in maintaining and reporting on long term datasets.

Gladys Chigamba, Ministry of Natural Resources and Climate Change, Department of Fisheries, Malawi. **Linthipe River Ecosystem: Unveiling Economic Dimensions for Sustainable Conservation and Livelihoods in Malawi.**

Many rivers worldwide, including the Linthipe River in the East African Rift Valley, need well-documented economic values that could persuade riparian countries to step up efforts to manage aquatic resources effectively. This study measured the value people derive from using the aquatic resources from the Linthipe River. Linthipe River as one of the major tributaries of Lake Malawi provides a lot of ecosystem services of high economic value. Data were collected randomly sampled from October 2019 to July 2020 through 391 households (74% male and 26% female). Data was collected using household questionnaires, document reviews, Key Informant Interviews (KIIs), Focus Group Discussions, field observations, Willingness to Pay (WTP) method. The study calculated the Gross Financial Value (GFV) from the data to estimate the economic values for direct-use services. At the same time, the Payout Level (PoL) for users' WTP provided the values for non-use services. The study revealed that the Total Economic Value of the Goods and Services generated from the Linthipe River was US Dollars (US$) 116,312.38 (US$16,172.08 GFV and USD 100,140.30 PoL). The study showed that the Linthipe River has a comparatively high economic value, which depicts the great significance of the river to the surrounding communities. This calls for all stakeholders to manage the rift valley rivers holistically.

Justin Chiotti[1], Zachary Amidon[2], Robin DeBruyne[3], Jason Fischer[1], Dimitry Gorsky[1], Philippa Kohn[4], James Markham[5], Christopher Olds[6], Stacy Provo[3], Edward Roseman[3] and Wendylee Stott[7], [1]U.S. Fish and Wildlife Service, [2]University of Toledo, [3]U.S. Geological Survey, [4]The Nature

Conservancy, [5]New York Department of Environmental Conservation, [6]U.S. Forest Service, [7]Fisheries and Oceans Canada. **Identifying and characterizing Lake Whitefish spawning habitat in Lake Erie.**

The Lake Whitefish population in Lake Erie crashed by the mid-1900s. Currently, catch rates are low, variable and spatially restricted to primarily the western basin, reflecting a trend in poor recruitment. Egg survival and available spawning habitat is suspected to be a major source of recruitment variability, however the extent of available spawning habitat is unknown. To identify locations where spawning is occurring, historic and predicted spawning areas were sampled along the southern shore of Lake Erie during the fall of 2021 and 2022 using egg mats and egg pumps. A total of 89 sites were sampled, consisting of 512 egg pump tows. Side scan sonar and GoPro camera drops collected substrate data at each site. Lake Whitefish and Lake Trout eggs were found at the Lorain, Fairport, Barcelona/Shorehaven, and Woodlawn Bar locations beginning in late November and persisting through December. Lake Whitefish eggs were not detected until water temperatures were below 5.5°C. Eggs were found over hard substrates at depths ranging from 3.7 to 8.0 m. Substrate, water depth, water temperature, and other metrics will be incorporated into occupancy models to determine the factors influencing Lake Whitefish spawning site selection. Identifying and characterizing coregonine spawning habitat will improve our understanding of various factors limiting recruitment and aid in population viability analysis.

Mwayi Chirwa[1], Gertrude Sebunya Muwanga[2], Robinson Odong[2] and Godfrey Kawooya Kubiriza[2], [1]Makerere University Graduate Student , [2]Makerere University. **Power dynamics and value chain of silver cyprinid in Lake Victoria, Uganda.**

Silver cyprinid, *Rastrineobola argentea*, commonly known as daaga, mukene, omena, holds significant importance in East Africa, sustaining numerous livelihoods. However, the escalating significance of this fish has altered the roles and power dynamics of various actors in the value chain, particularly at major landing sites on Lake Victoria. This study, conducted at Kiyindi landing site on the Ugandan side of Lake Victoria, examines the characteristics and roles of actors in decision-making, price determination, and trade within the silver cyprinid value chain. Results categorize actors into primary (fishers, processors, wholesalers, transporters, and retailers) and secondary (commission agents, input suppliers, and fisheries officers). Processors and wholesalers emerge as central figures in marketing and distribution, exerting considerable influence. The trade of silver cyprinid demonstrates that few buyers holding more power than sellers by 72%. Fishers, while influencing fresh fish prices, predominantly act as price takers 100%. Wholesalers and retailers wield perfect competitive power in price determination. Processors and commission agents significantly influence purchasing and selling prices. Power imbalances, influenced by industry knowledge and capital opportunities, favor processors and wholesalers, marking them dominant actors. Primary actors, commission agents, and input suppliers exhibit bargaining and demonstrative powers within the chain while government exert institutional, constructive, and demonstrative influence. The study recommends interventions by government to address power imbalances among actors, ensuring the sustainability of small pelagic fishes.

Keoni Chong[1], Yingming Zhao[2] and Josef Ackerman[1], [1]University of Guelph, [2]MNRF. **Navigating turbulence: the effects of eddy size on the swimming performance of walleye (Sander vitreus) larvae.**

Natural populations of walleye experience large interannual fluctuations due to substantial die-offs during their larval stage. To understand the mechanisms underlying recruitment success in walleye larvae, we conducted experiments in a recirculating flow chamber to evaluate critical

swimming speeds, a measure of maximum sustainable swimming speeds, and feeding rates in response to turbulence along their larval development. Turbulence was generated using an upstream grid to propagate eddies, circulating turbulent structures, of varying sizes that larvae had to navigate. We found that swimming was significantly impeded when the diameter of turbulent eddies was roughly two-thirds the size of the larvae. Despite this, larvae were still able to resist and swim against turbulent flows. Feeding was first detected in their third week of development, which coincided with the largest increase in swimming speeds and access to inertial flow regimes. Our swimming evaluation show that weak swimming abilities may limit feeding early in development and larvae likely rely on strong currents for long-distance transport until they develop a competent swimming ability. Since larval fish rely on swimming to control dispersal, hunt prey, and evade predators, unfavourable turbulent conditions in nature could negatively impact the growth and survival of larval walleye. Our findings could inform walleye conservation efforts by providing swimming parameters necessary for realistic larval drift models and inform stocking decisions based on larval performance predictions to optimize recruitment success.

Anson Chow and Mathew Wells, University of Toronto. **A dramatic delay in fall overturn dates in a 25-year stratification record from a dimictic lake.**

Dimictic lakes are ubiquitous in the Great Lakes region and are the most common lakes world-wide. Due to climate change the timing of fall mixing is shifting, with profound implications to many important ecological processes. The mixing during fall overturn is driven by a combination of convective mixing from cold air and mechanical mixing from strong wind events. Using a 25-year record of thermal stratification from Lake Opeongo, a large dimictic lake in the Algonquin Park in Ontario, Canada, we explore how the timing of fall overturn has shifted. Historically, earlier fall overturn dates of September 29th were common before 2000, and now after 2020 fall overturn starts as late as October 27th. This appears to be in part due to declining wind speeds, which dropped by nearly 20% over the 20-year wind record. For the earlier fall overturns (due to stronger wind), the mixed water column usually was warmer (as high as 14.3°C), whereas with lower wind the later overturns occurred when the water column has cooled down more and full mixing occurred as low as 9.2°C. We will discuss how the changes in the timing and temperature of the fall overturn likely impact the habitat conditions and food availability for fish species in dimictic lakes, and present observation from a fish telemetry study documenting the sudden changes in seasonal habitat usage of the summer and fall water-column.

Ryanne Cimatu[1], Justin Myers[1], Stephen Jacquemin[1], Morgan Jutte[1] and Silvia Newell[1, 2], [1]Wright State University, [2]University of Michigan. **Closing the Gap: Nitrogen Dynamics in the Maumee River.**

Excess anthropogenic nitrogen (N), primarily from agricultural fields, causes nutrient runoff that stimulates harmful algal blooms (HABs) in surface waters. As a critical tributary to Lake Erie, nutrient loading from the Maumee River drives the intensity of the annual summer HABs in the western basin. Knowledge gaps around rates of N transformations in the Maumee River currently hinder calibration of in-river parameters in SWAT (Soil and Water Assessment Tool) models for the Maumee watershed. To address these gaps, this research aims to quantify rates of ammonium uptake, ammonium remineralization, nitrification, and bacterial respiration in addition to the physicochemical parameters of the river. Monthly sampling was conducted along the Maumee River from International Park (river mile 4.53) , Mary Jane Thurston (river mile 31.88), and Independence Dam (river mile 59.31) over the course of a year. Ammonium uptake rates ranged from 1.2 to 8.7 μmol N L^{-1} hr^{-1} for water samples incubated under light conditions and from 0.2 to 1.9 μmol N L^{-1}

hr^{-1} under dark conditions, while ammonium regeneration ranged from not detectable to 12.0 µmol O_2 L^{-1} hr^{-1}. Bacterial respiration rates averaged 525.0 ± 28.5 µM O_2. These findings will be incorporated to parameterize a SWAT model across a variety of seasonal conditions within and along the Maumee River.

Natalia Cislo, **Oumaima Fares**, Timothy Simmons, Neal Ma, Quinn Alami, Dimitris Anastasiou, Jason Jeong and Sanjita Satish, Columbia University. **Powering Non-Powered Dams in the Great Lakes Region.**

Over the last century, many high-quality dams were built in the Great Lakes region, and now they offer the perfect opportunity to be turned into powered hydroelectric plants. With many of the environmental concerns of hydropower plants resulting from just the dam construction, converting non-powered dams to powered dams offers an environmentally conscious, time-efficient, and cost-effective way to add renewable energy sources to the region. The capacity potential of these non-powered dams on the U.S. side can reach more than 1.5 GW, indicating the vast opportunity to add new renewable assets to the region's grid. Many of these dams could even be converted to pumped storage hydroelectric plants, offering new energy storage potential in the area. In our presentation, we will highlight the most promising dams in the region and outline the conversion processes and tactics.

Jacob Cochran and Jason Coombs, U.S. Fish and Wildlife Service. **A Scalable Data Acquisition and Dissemination System for Environmental DNA Projects.**

The use of environmental DNA (eDNA) for inventory and monitoring applications is increasingly being applied to aquatic conservation. Single and multi-species eDNA detection methods, such as quantitative PCR (qPCR) and metabarcoding, are being implemented for detection of both native and invasive fish species across the Great Lakes region. This increase in eDNA sample collection has led to the need for more efficient and standardized information acquisition and dissemination systems. Here, we share an eDNA data workflow for eDNA water filtration sample collections that has successfully managed over 2,000 samples across 12 independent eDNA projects. Sample collection data are submitted through a digital collection form via smart devices in the field and automatically uploaded to a cloud-based repository. Filter packs used for sample filtration are affixed with barcodes that serve as unique identifiers and are fundamental to sample tracking and relation. Following lab processing and bioinformatic analysis, positive replicate (qPCR) and taxonomic assignment (metabarcoding) results are related back to sample data in the repository. End-user products for visualization and interpretation of results are generated in the form of data dashboards and automated summary reports. This workflow incorporates concepts that increase efficiency and improve quality control. Additionally, this system is inherently able to scale up as sample sizes increase. Ideologies from this workflow can also be extended beyond eDNA, benefitting other disciplines where data collaboration and sample tracking are required.

Jeanne L. Coffin-Schmitt[1], Vivian Nguyen[2], Amelia Grainer Safi[1], Richard Stedman[1], Renata Ivanek[1] and Kathryn J. Fiorella[1], [1]Cornell University, [2]Carleton University. **Urban fishers demonstrate diverse perceptions and practices within the Niagara River Area of Concern.**

Urban fishers are a distinct sub-group of recreational fisheries including socially vulnerable individuals (i.e., low socio-economic status, minoritized groups, and recent immigrants). Vulnerable fishers may fish for food security, nutrition, or socio-cultural purposes to a greater extent than the expected typical recreational fisher. Additionally, urban fishing sites in the Great Lakes are often part of complex social-ecological systems under management for legacy contaminants of concern (i.e.,

polychlorinated biphenyls). Understanding the perceptions and concerns of local communities could steer continued restoration efforts and policies. This case study uses semi-structured interviews (n=49) with diverse urban fishers intercepted while fishing the Niagara River Area of Concern to probe motivations, preferences, and risk and benefit perceptions related to local fish consumption. Most fishers (60%) perceived that risks arise from eating local fish, while others did not or were unsure. Fishers asked about transparent and timely updates on water quality and fish contaminant levels. Reported fish consumption varied widely (0-16 fish meals per month), with higher consumption more common in fishers reporting cultural or food and nutrition related motivations. Some ethnic groups also report distinct fish consumption practices. Nearly all fishers reported intangible benefits (mental health and social bonding). Great Lakes fishing policy tends to be framed for economically powerful fisheries, e.g., sport and commercial fishing, but this research indicates how institutional support for the needs of vulnerable fishers can improve.

Paris Collingsworth[1], Annie Scofield[2] and David Depew[3], [1]Purdue University - Illinois Indiana Sea Grant, [2]EPA-GLNPO, [3]Environment Climate Change Canada. **Overview of Lake Huron CSMI activities during the 2022 intensive field year.**

Annex 10 (Science Annex) of the Great Lakes Water Quality Agreement (GLWQA) coordinates the binational Cooperative Science and Monitoring Initiative (CSMI) in support of Great Lakes ecosystem assessment and management. The CSMI process includes enhanced monitoring and science-based field activities conducted in one Great Lake per year, which are implemented in support of science priorities identified by the GLWQA Annex 2 Lake Partnerships. The 2022 Lake Huron CSMI investigations by federal agencies and partners addressed key knowledge gaps among five science priority themes including chemical contaminant pollution, nutrient and bacterial pollution, habitat and native species, invasive species, and other stressors. Here, we will provide an overview of the CSMI five-year cycle that involves the development of science priorities, field year planning, intensive field year science and monitoring, analysis, and reporting to decision-makers. A summary of field activities that took place during the Lake Huron CSMI field year will be shared, and next steps for reporting results of the 2022 effort will be highlighted.

Steven Cooke, Carleton University. **Modelling what professional service should be - the Bill Taylor approach.**

Dr. William (Bill) Taylor has had an illustrious career as a scientist and educator which in many ways is what is "expected" of those in the professoriate. However, what truly differentiates Bill from others is his willingness to serve our profession and do so in diverse ways that benefit all of us and the environment. I was fortunate to be able to observe Bill "model" what professional service should be from the first time we met when he was serving as President of the American Fisheries Society and presiding over the Governing Board Meeting in Bethesda; I attended as a student. I continued to re-connect with Bill over my career and quickly learned from him that being active in one's profession was the perfect way to give back while at the same time enriching one's career. I was fortunate to be able to sit beside Bill to learn from him how to be a balanced and effective Chair for various committees of the Great Lakes Fishery Commission. He always excelled at ensuring that all voices were heard and that interactions, even on difficult topics, were always civilized and intelligent. In this presentation I will reflect on Bill's service to our profession with a focus on his contributions to the American Fisheries Society but will also identify examples of where that service and his learnings have spilled over into other domains.

Patricia Corcoran[1], Alexa Holland[1], Bethany Dean[1], Natalie Minda[2], Emma Arnew[1] and Jonathan Gijzen[1], [1]Western University, [2]University of Toronto. **An Update on the Factors Controlling Plastic Debris Deposition in Urban Stormwater Ponds of London, Ontario, Canada.**

Stormwater ponds capture run-off during precipitation events and enable sediment and contaminants to settle prior to the release of water into natural basins. Macroplastics (MaPs) and microplastics (MPs) from 8 ponds in London, Ontario provide a glimpse into the main factors controlling plastic debris deposition. Of the 52 sample sites, the average number of MaPs (not including fragments and expanded polystyrene) was 0.5 m^{-2}, with a range of 0 to 4 items m^{-2}. The ten most common MaPs were cigarette butts, food wrappers, beverage bottles, bottle caps, bags (general), dog poop bags, cigar tips, cups, straws, and medical masks. Microplastic abundances ranged from 0-242,099 particles per kg of dry weight sediment (kg^{-1} dw), with an average of 11,901 kg^{-1} dw for all ponds. The average concentration of MPs in the sediment forebays was 22,001 kg^{-1} dw and in the main basins was 6343 kg^{-1} dw. The MPs are represented by fragments (77%), fibers (22%), glitter (0.5%), and beads (0.5%). Dividing the city into four quadrants, the largest concentration of MPs was found in southeast London (53%), followed by the southwest (26%), northeast (11.5%), and northwest (9.5%). The next steps will involve comparison of plastic pollution from all 28 ponds sampled, and determining the influence of grain size, inlet drain proximity, pond geometry, socioeconomic factors, and last date dredged on microplastic abundances.

Peter Czajkowski[1], **Marjorie Cort**[1], Gail Krantzberg[2], Andrew Gronewold[2], Carolyn Johns[3, 4], Kyle Whyte[3, 4] and Dawn Martin-Hill[3, 4], [1]Project Manager, [2]Principal Investigator, [3]Researcher, [4]Co-PI. **The Global Center for Understanding Climate Change Impacts on Transboundary Waters.**

The mission of the recently launched Global Center (GC) for Understanding Climate Change Impacts on Transboundary Waters aligns with the objectives of the IJC's *Great Lakes Decadal Science Plan* of 2022, which aims to "establish a road map for placing the Great Lakes region on a sound scientific footing for ensuring effective management and permanent sustainability of the system." As a multinational center, the GC's research focuses on mitigating climate change impacts on water resources and addressing regional requirements for sustainable hydrologic management that supports community, governance, and ecosystem sustainability. The GC was established to develop an adaptive management framework that addresses gaps in the management of transboundary water systems characterized by diverse governance structures and stakeholder groups. The GC will address deficiencies in coordinating collaborative scientific resources and encompassing shared data and model development with the Great Lakes serving as an initial focal point. The GC aims to enhance the resilience of vulnerable communities through outreach and the integration of Traditional Ecological Knowledge (TEK) across three core themes: 1) the development of reliable predictions of future hydrologic conditions in response to climate change; 2) the co-production of research incorporating TEK, water quality monitoring, and modeling protocols and frameworks; and 3) capacity-building for governance and management systems that incorporate TEK and the input of traditionally marginalized communities to increase disaster resilience across multiple scales.

Megan Cort[1, 2], Altaf Arain[2, 3], Paulin Coulibaly[2, 3], Peter Czajkowski[2, 3], Jennifer Gauthier[2, 4], Andrew Gronewold[1, 2], Carolyn Johns[2, 5], Gail Krantzberg[2, 3], Dawn Martin-Hill[2, 3], Richard Norton[1, 2], Scott Steinschneider[2, 6] and Kyle Whyte[1, 2], [1]University of Michigan, [2]Global Center for Understanding Climate Change Impacts on Transboundary Waters, [3]McMaster University, [4]College of Menominee Nation, [5]Toronto Metropolitan University, [6]Cornell University. **Science Across Borders: The Global Center for Understanding Climate Change Impacts on Transboundary Waters.**

The recently launched Global Center (GC) for Understanding Climate Change Impacts on Transboundary Waters addresses the complexities of managing water systems that span multiple jurisdictions and sovereign nations. The GC comprises researchers and partners from Indigenous Nations, the US, and Canada, and aims to develop and apply multi-national collaborative and interdisciplinary science. The Great Lakes serve as the initial focal point for the GC's global research vision, which is centered on three core themes: 1) developing predictive models for future hydroclimate conditions utilizing data resources across US and Canadian boundaries; 2) co-producing research that incorporates Traditional Ecological Knowledge (TEK) of Indigenous Sovereign Nations with conventional ecosystem and water quality monitoring and modeling protocols; and 3) capacity-building for governance and management systems that incorporate TEK and the input of traditionally marginalized communities to develop governance and management models. Integrating research across multiple sovereign nations, institutions, and disciplines poses various benefits and challenges. Benefits include novel research outputs, the integration of marginalized voices into the research dialogue, and the creation of usable scientific outputs. Challenges include managing data coordination across boundaries, reconciling practices - cultural and research-related - and developing deliverables that support the various needs of diverse groups.

Colleen Cosgrove, Nathan Manning and Laura Johnson, Heidelberg University. **Not all loads are estimated equal: Comparing load estimators across sampling frequencies and river size.**

There has been a pointed effort to reduce nutrient loads of phosphorus from tributaries entering Lake Erie over the last decade to reduce harmful algal blooms. In order to determine how well that reduction is being achieved and its effects on the health of the lake, it is imperative to have the most accurate nutrient load estimations possible. There are a number of load methodologies, including manual calculations, USGS's LoadFlex and WRTDS, GCLAS, and Beale's Ratio Estimators. While each of these approaches have their own biases and accuracies based on sampling frequency and data available, there are few guidelines for selecting one estimator over another. To ensure the highest accuracy in loads, we need to evaluate whether each estimator should be used exclusively among different sampling frequencies, river sizes, and potential weather scenarios. To do this, we are running various simulations to determine which estimation method best suits each river size and scenario type. Daily/ sub-daily frequency of data at the NCWQR allows us to extensively test each scenario. This will allow us to create a useful guide for load estimator selection based on a number of sampling scenarios that include sampling frequency and river size. Knowing which method to select will provide the best estimated input to the lake, which, in the Great Lakes region, is important for harmful algal bloom mitigation and, ultimately, human health, safety, and recreation.

Anika Craft, **Sabrina Brown** and **Mollie Sorrell**, Defiance College. **Establishing an Undergraduate Research Program Focused on Long-Term Water Quality Assessment in Defiance, OH USA.**

The Maumee River watershed covers more than 6,500 mi^2 and two of its largest tributaries, the Tiffin and Auglaize Rivers, enter the Maumee River in Defiance, Ohio. The goal of this research is to establish a long-term assessment program of the water quality in the Upper Maumee River Watershed using chemical analysis, streamflow, and bioassessment utilizing diatom assemblages. Here we provide preliminary results from a field collection of sites on the Maumee River and tributaries conducted from 2021-2023. Four sites were chosen and sampled over three subsequent six-week periods from May-June 2021, 2022, and 2023. Sites included the Tiffin and Auglaize Rivers; and two sites along the Maumee; one prior to confluence with the Tiffin, the other past confluence with the Auglaize. Results indicate that the Auglaize had the most turbid water with the lowest

average levels of dissolved oxygen. This site also had the highest levels of nitrates, nitrites, and ammonia, and exhibited a lower average streamflow than both Maumee River sites. Diatom assemblages were dominated by *Fragilaria*, *Aulacoseira*, and *Navicula*. The Tiffin River had the highest diversity in diatom and macroinvertebrate communities with species indicative of high nutrient availability. Plankton tows at the Auglaize had a high percentage of benthic species present, indicating relatively turbid conditions. Both Maumee sites had similar species compositions, dominated by *Aulacoseira*, with an influx of *Stephanodiscus,* at the end of the sampling period.

Chelsea Crundwell[1, 2], Lori Phillips[2], Craig Druury[2] and Christopher Weisener[1], [1]Great Lakes Institute for Environmental Research, [2]Agriculture and Agri-Food Canada. **Investigating Microbial Triggers of Greenhouse Gas Emissions in Agriculturally Influenced Aquatic Ecosystems.**

In Canada, the agriculture sector was responsible for approximately 10% of greenhouse gas (GHG) emissions in 2021, accounting for 54 MT of carbon dioxide (CO_2), as well as 31% of methane (CH_4) and 75% of national nitrous oxide (N_2O) emissions. These estimates, however, do not include the indirect GHG emissions from agriculturally impacted waterways in the Great Lakes. Windsor-Essex County in Southwestern Ontario, Canada, has over 3000km of agricultural drainage ditches, collecting nutrient rich runoff from tiled fields and impacting both Lake St. Clair and Lake Erie. These ephemeral zero-order waterways experience fluxes of different types of excess nutrients, which creates nutrient hotspots and may disrupt baseline biogeochemical cycling of C, N, and P. In this study we investigate whether these disruptions also impact GHG from the ditches. To resolve GHG driving factors in these systems, microbial activity at the sediment-water interface was correlated with N_2O, CO_2 and CH_4 emissions, collected over a season during fertilizer application and crop turnover. Additionally, the presence or absence of riparian vegetation was compared to understand the impacts of dredging on microbial activity and GHG emissions. Microbial community responses were assessed using a combination of molecular approaches targeting key archaeal and bacterial genes in the C and N cycle.

Brianna Curtis and Catherine Febria, University of Windsor. **Quantifying the influence of riverine infrastructure on Unionidae species-at-risk communities in the Grand River watershed.**

Urbanization has largely led Unionidae population declines, giving rise to species-at-risk (SAR) statuses for various species. In areas of riverine infrastructure development (i.e., dams), translocations of Unionidae SAR are a common conservation strategy, despite research showing limited recover success post-translocation. When considering Unionidae translocations for infrastructure developments and alterations, many species habitats do not undergo rigorous assessment. Although dams are essential infrastructure for various services, assessing this type of infrastructure for SAR mitigation strategies occurring within the same river system is critical. As dam infrastructure poses a physical barrier to freshwater communities, accounting for their impact on in-stream communities can ensure that translocated SAR have the greatest chance of successful recovery. This study investigates stream habitats and Unionidae communities surrounding dam infrastructure within the Grand River watershed. Our research asks: What is the impact of riverine infrastructure on Unionid mussel communities and their habitats? We hypothesize that habitats downstream of dams will be more suitable for Unionidae given the oxygenation and quality of riffle habitats whereas areas upstream of dams will be deeper, slower-flowing and consisting of finer sediments. A comprehensive in-stream assessment of seven run-of-the-river dams was conducted for benthic macroinvertebrate communities and habitat analyses to determine the suitability of

Unionids and potentially explain the decline of SAR mussels due to connectivity. Preliminary findings for water quality and benthic macroinvertebrate taxa were analyzed in preparation for Unionidae populations assessments.

Kevin Czajkowski[1], Janet Struble[1], Sara Mierzwiak[1], Vicki Harder-Thorne[2], Bo Lebo[3], Yitong Jiang[1], Oluwafemi Olawale[1] and Farrokh Namjooyan[1], [1]University of Toledo, [2]Earth Heart Farms, [3]New Education Options. **Water Quality in the Maumee Watershed Through Student Engagement: GLOBE at Earth Heart Farms.**

Many students have never taken observations of their environment. They have never been engaged in real science and they do not know about algae blooms on Lake Erie, their causes and impacts. The University of Toledo - through its NASA funded GLOBE Mission EARTH Project and funding from Ohio EPA Environmental Education Fund and NOAA B-Wet Programs - has led professional development for teachers and field days for students at Vicki Harder-Thorne's family-owned Earth Heart Farms (EHFs). EHF was taken out of production 30 years ago and put into conservation. This past year, through the H2Ohio Program, a wetland was installed on the land and native trees were planted in riparian zones. Teacher professional development was held in the summer and focused on learning GLOBE protocols for taking water quality, soil characteristics and atmospheric observations as well as conservation approaches to promote the ecosystem. Volunteer conservationists from the Ohio Department of Natural Resources (ODNR), Green Creek Wildlife Society, Black Swamp Bird Observatory, and Friends of Ottawa National Wildlife Refuge led the teachers and then students on hikes through the 80 acres helping the students identify bird species, animal tracks, insects and plants. Students attended field days in the fall and spring on the land and then complete scientific projects related to the wetland, landscape, and nutrient transport to Lake Erie. They learned how their actions can change nutrient runoff and water quality.

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Lauren Damphousse[1, 2], Todd Morris[3, 4] and Catherine Febria[1, 2, 4], [1]University of Windsor, [2]Integrative Biology, [3]Fisheries and Oceans Canada, [4]GLIER. **Mitigation Translocations: Investigating freshwater mussel SAR recovery post-relocation.**

Freshwater mussels (Unionidae) serve as critical structural and functional links for aquatic food webs and are bioindicators of ecosystem health. Unfortunately, many species are declining globally, including in Canada where many are listed as species-at-risk of extinction (SAR). Restricted in their ability to move readily throughout riverbed habitats, Unionidae are vulnerable to human activities such as infrastructure projects, which can take place in or adjacent to rivers. Translocation efforts are a common mitigation response under the federal Fisheries and Species at Risk Act. Since publication of a standardized protocol for freshwater mussel translocations (Mackie et al. 2008), practitioners have been conducting translocations with little to no follow-up or evaluation of this practice. To address this, we synthesized translocation reports spanning 15 years. Additionally, sites of previous translocations in the Grand and Thames River watersheds located in southern Ontario were surveyed during 2022 to expand upon the submitted reports. Together these data were combined to assess the long term effectiveness of SAR policy. Preliminary findings indicate that mussel communities do not fully recover following translocation, negatively affecting overall population density and biodiversity of freshwater communities. To further understand these poor rates of recovery, an experimental translocation was performed in the Sydenham River in 2023. My research offers evidence to improve conservation within the species-at-risk policy and practice in

support of coordinated actions including habitat restoration and benthic macroinvertebrate community indicators.

Susan Daniel, Lyubov Burlakova, Alexander Karatayev and Lillian Denecke, SUNY Buffalo State University. **Invasion dynamics of New Zealand mud snail (*Potamopyrgus antipodarum*) in the Laurentian Great Lakes.**

The New Zealand Mud Snail (*Potamopyrgus antipodarum*) is an invasive mollusk that was first reported in lakes Ontario in 1991, Superior in 2005, Michigan in 2006, and Erie in 2007. In 2022, we found a small population in the North Channel representing the first record of this snail in Lake Huron. To understand the status of this species in the Great Lakes, we combined data from the Great Lakes National Program Office Great Lakes Biology Monitoring Program and the Cooperative Science and Monitoring Initiative sampling efforts, data from publications, regional reports, and online databases. In the last three decades *P. antipodarum* has spread to all Great Lakes, and the rate of invasion increased 4-fold during the last decade. The highest density was observed in Lake Michigan, followed by lakes Ontario, Erie, and Huron. In Lake Michigan in 2021, *P. antipodarum* lake-wide density increased 56-fold compared to 2015, comprising 93% of the total gastropod density and 79% of biomass. This spread in Lake Michigan may have been facilitated by invasive *Dreissena* spp. through stimulation of bottom algae and periphyton growth. While *P. antipodarum* is still spreading in lakes Michigan and Huron, its abundance remains stable in lakes Erie, Ontario, and Superior.

Ericka De Oliveira[1], Paul Helm[2] and Roxana Suehring[1], [1]Toronto Metropolitan University, [2]Ministry of the Environment, Conservation and Parks. **Passive Sampling for the Identification of Persistent, Mobile, and Toxic (PMT) Substances in Lake Ontario.**

Plastic associated contaminants, particularly plastic additives, pose a significant threat to aquatic environments, one which has coincided with the global growth in plastic waste. Plastic additives that are persistent, *mobile*, and toxic (PMT) are of specific concern due to their mobility in water. Many PMT plastic additives are expected to bypass water treatment processes, meaning they could pose a substantial long-term health risk to environments and humans. Few studies have demonstrated the use of passive sampling to measure PMTs, and none have focused on Canadian waters such as the Great Lakes basin, which contain excessive amounts of plastic contamination. Here we present the use of passive sampling for the capture of PMT plastic additives in Lake Ontario. This study investigated the use of polydimethylsiloxane (PDMS) strips and Polar Organic Chemical Integrative (POCIS) samplers with polyether sulfone (PES) membranes and hydrophilic-lipophilic balance (HLB) receiving disks. The samplers were placed at five stations in the lake (Hamilton Harbour, Etobicoke Creek, Humber Bay, Pickering, Ajax), to investigate the levels of PMT contamination and whether spatial factors led to differences in PMT plastic additive patterns. Samples were screened against a library of 124 PMTs to tentatively identify suspects captured at the sampling locations. The results from this study aim to provide governments and regulators with a prioritization list of PMT plastic additives, to inform future monitoring strategies and to enable their regulation in Canada.

Robin DeBruyne[1], Lauren Fry[2], Ashley Moerke[3] and Edward Roseman[1], [1]US Geological Survey Great Lakes Science Center, [2]NOAA Great Lakes Environmental Research Laboratory, [3]Lake Superior State University. **Great Lakes Connecting Waters Collaborative: Introductory Summit to Frame Needs and Next Steps.**

The Great Lakes connecting waters link the five Great Lakes to each other and Atlantic Ocean, and historically these systems possessed pristine water quality and resources that supported Indigenous Nations communities and offered vast amounts of functional habitat for fish and wildlife. Currently, many areas of the connecting waters have degraded water quality and habitat due to development, urbanization, industry, and channel modification. Improving conditions and establishing healthy relationships with aquatic resources involves interjurisdictional cooperation and collaboration. A Great Lakes Connecting Waters Summit brought together research and monitoring practitioners to draft a viable framework to address the concerns and suggestions outlined in a recent IJC report detailing environmental monitoring and research needs for these important waterways and habitats. Participants worked in small groups to draft a collaborative framework to facilitate coordinated research and monitoring activities while allowing for place-based needs and priorities. The presence of a backbone entity was deemed critical to provide science support and facilitate science and technology transfer between individual connecting waters networks. Engaging rightsholders and underrepresented stakeholders during collaborative development will be essential. Participants also identified challenges and next steps including broadening input scope and identifying a potential backbone entity and funding source. This is the first step to coordinate and establish a Great Lakes Connecting Waters Collaborative aimed at improving research and monitoring in the connecting waters and meeting the needs of the local communities.

Paul Den Uyl[1, 2], E. Anders Kiledal[2], Subba Rao Chaganti[1], Reagan Errera[3], Casey Godwin[1] and Gregory Dick[1, 2], [1]Cooperative Institute for Great Lakes Research, [2]Department of Earth and Environmental Sciences, University of Michigan, [3]Great Lakes Environmental Research Laboratory.
Genetic Characterization of Saxitoxin Producing Cyanobacteria from W. Lake Erie Harmful Algal Blooms.

Saxitoxins (STXs) are neurotoxins produced in both freshwater and marine systems and are among the most potent known natural toxins. While genes encoding STX biosynthesis have been observed in Lake Erie, the organism(s) responsible for producing STXs in the region have not been confirmed. We used metagenomic tools to identify a full suite of STX biosynthesis genes in a high-quality metagenome-assembled genome (MAG) from the Anabaena-Dolichospermum-Aphanizomenon (ADA) clade of cyanobacteria. The order and sequence of *sxt* genes suggest the Lake Erie MAG is likely capable of producing saxitoxin (STX) and dicarbamoyl (dcSTX) congeners. The absence of a *sxtX* gene suggests an inability to produce neoSTX, one of the most potent variants of STX. We also recovered highly similar ADA MAGs that did not contain *sxt* genes, implying gene loss or horizontal gene transfer. We observed the full suite of STX biosynthesis genes in metagenomic datasets across 13 of 123 unique sampling dates between 2014 and 2022, with occurrences spanning from July 6 to September 19. A qPCR dataset targeting *sxtA* detected the gene in 49 of 76 sample dates collected between 2015 and 2019 and is being used to identify environmental conditions that correlate with STX production potential.

Mitchel Dender, Parsons. **A Brief Overview of Fisheries Offsetting and Compensation in Ontario's Construction Landscape.**

To facilitate construction, fisheries offsetting in Ontario refers to the strategies and practices implemented by biologists prior to or during construction. The goal of these offsetting plans is to compensate for adverse impacts on aquatic ecosystems and acquire permits that will facilitate construction projects. This presentation explores the different types of offsetting strategies implemented in Ontario and their effectiveness in mitigating the impacts of construction on the natural environment. There is a diversity of offsetting strategies implemented across Ontario

including wetland restorations, restocking programs, erosion control and habitat installations which are all common practices found in offsetting programs. It will also explore the challenges associated with evaluating the outcomes of these initiatives, including difficulties in measuring biodiversity and assessing long-term impacts. The presentation will highlight best practices for fisheries offsetting and compensation, including the importance of collaboration between stakeholders, effective monitoring, evaluation programs, and ongoing research into new techniques for mitigating the impacts of construction projects on fish populations. By taking a step back and unpacking the consultant's toolkit, we will have a better understanding of what types of offsetting is available and how effective it is to harmonize developmental goals and ecological preservation for smoother construction and stronger ecosystems.

Lillian E. Denecke, Lyubov E. Burlakova, Alexander Y. Karatayev and Susan E. Daniel, Buffalo State University. **Distribution of Round Goby across depth zones in The Laurentian Great Lakes.**

The Round Goby (*Neogobius melanostomus*) is an invasive benthic predator in the Laurentian Great Lakes that caused local displacement of native benthic fishes and has become an important prey item for native and nonnative piscivores. To access goby abundance, we collected video footage using a Benthic Imaging System equipped with GoPro cameras from lakes Huron, Michigan, Erie, and Ontario as part of the CSMI benthic surveys. Three replicate videos from each station were analyzed to count the number of round gobies present when the camera frame landed. Gobies were most commonly found at <30 m depth with an average count of 1.0 ± 1.4 SD (Ontario, 2018), 2.0 ± 5.7 (Ontario, 2023), 0.1 ± 0.3 (Erie, 2019), 0.1 ± 0.3 (Michigan, 2021), and 0.2 ± 0.4 (Huron, 2022). Gobies were present to a maximum depth of 76 m in Lake Ontario. Maximum round goby counts for each lake were found between the depths of 11 m in Lake Ontario (34.3, at the mouth of the Twelve-mile Creek) to 21 m in Lake Michigan (1.3). Continued monitoring of round goby abundance is vital for understanding of their relative abundance and depth distribution in the Great Lakes.

Vincent Denef, University of Michigan. **Trait variation in nutrient requirements and predation resistance to understand *Microcystis* genotypic succession.**

Microcystis is a phylogenetically cohesive group of cyanobacteria marked by extensive genetic diversity. In field observations in Western Lake Erie, complex dynamics in which different genotypes of *Microcystis* predominate across time (across weeks and years) have been observed. We determined that different genotypes isolated for Western Lake Erie diverge in the minimal concentrations of N and P at which they can maintain growth. These data allow us to predict competitive hierarchies that may explain field observations. Yet, when compared to eukaryotic green algae, typically preceding cyanobacteria in north-temperate lakes, ecological theory predicts, and our experiments confirm, that *Microcystis* is generally outcompeted by green algae, except for coexistence at high N:P ratios. These results were robust at 20 and 25 C, even though increased temperature is often cited as an important factor increasing *Microcystis* competitive abilities. This emphasizes the important, and previously shown, role of predators to the success of *Microcystis* in the field. We observed significant genotypic variation in the susceptibility of Western Lake Erie Microcystis genotypes to predation by dreissenid mussels and *Daphnia*, which correlated to variation in the diversity of secondary metabolites they produce. We plan to integrate these trait data to model *Microcystis* genotype-level succession patterns in Western Lake Erie.

David Depew, Tyler Harrow-Lyle and Andrew Bramburger, Environment and Climate Change Canada. **Benthic and pelagic productivity across a nutrient gradient in Lake Ontario.**

Concurrent measurements of *in-situ* benthic and pelagic primary production were collected in 2023 at three sites in Lake Ontario to assess sensitivity to contrasting phosphorus, light and temperature regimes. Benthic production was measured using a deployable eddy-covariance system and pelagic production measured using 14-C tracer techniques. These data will provide up to date information on the relative balance of benthic and pelagic production rates, and seek to inform future modeling work to assess the importance of benthic and pelagic production in supporting Lake Ontario productivity.

Lisa Derickx[1], Paula Antunes[2, 3], Mike Ripley[4], Aubrey Maccoux-LeDuc[5] and Peter Greve[4], [1]St. Marys River Remedial Action Plan, Algoma University, [2]Nautilus Environmental, [3]Algoma University, Department of Biology, [4]St. Marys River Binational Public Advisory Council, [5]Bay Mills Indian Community Biological Services Department. **A journey towards restoration: past, present and future of the St. Marys River AOC.**

The St. Marys River is one of 43 Areas of Concern (AOCs) identified under the *Canada-U.S. Great Lakes Water Quality Agreement*. This binational agreement commits to develop and implement Remedial Action Plans (RAPs) using a comprehensive ecosystem approach to restore environmental conditions in AOCs. Interjurisdictional participation of other levels of government, Indigenous communities, area stakeholders and the public is central to this work. To continue to make progress towards environmental restoration and move toward delisting the AOC, it is critical to evaluate work completed according to established restoration goals (delisting criteria) and identify work remaining under the RAP. The first phase of the RAP identified the environmental problems and sources of pollution within the AOC. Fourteen beneficial uses were used to assess the status of the AOC, of which nine were originally deemed impaired for the St. Marys River, and one required further assessment. During the second phase, over 50 remedial actions and monitoring initiatives were identified to help restore the impaired beneficial uses. With the implementation of many of these remedial actions, five beneficial uses have now been redesignated to a not-impaired status. This review outlines past, present and future/planned initiatives of the St. Marys River RAP, it also explains actions required to achieve delisting on the Canadian side of the St. Marys River AOC, and outlines successes specific to bi-national collaboration.

Georgia Bock, **Emilie DeRochie** and **Abraham Francis**, River Institute. **The River Strategy: Inclusive and Equitable Connection on the Kaniatarowanenneh (St. Lawrence River).**

The Kahnekarónnion (River) Strategy Collective is a new initiative that aims to facilitate increased inclusive and equitable communication and collaboration along the Kaniatarowanenneh (St. Lawrence River) and beyond. This multi-national initiative was founded in partnership by the St. Lawrence River Institute and the Mohawk Council of Akwesasne, and facilitates connection guided by a Kaswentha (Two Row Wampum) approach, and includes Indigenous Knowledge, Western Science, and local knowledge. To achieve increased communication and collaboration, the River Strategy Collective cultivates a community agreed-upon, value-informed space for people and organizations from across the region to gather, connect with each other, share knowledge and information, and identify opportunities to work together towards shared goals for the river. This presentation will highlight why a River Strategy Collective is needed and will describe logistics, challenges, and successes and processes of this initiative to date. Successes include meetings that have brought together diverse voices from across the region, the development of a multi-national Steering Committee, and identification of themes of interest for potential subcommittees and

working groups. The enthusiasm for the initiative has been demonstrated through the high level of participation by organizations and individuals involved. A commitment to inclusivity and relationship building is critical for providing a strong foundation to achieve the vision of a beautiful and healthy Kaniatarowanenneh (St. Lawrence River) for all.

Emilie DeRochie[1, 2], [1]River Institute, [2]Lakehead University. **Inspiring Action for the Great Lakes: The Great River Rapport's Change Maker Series.**

Introducing the Great River Rapport's Change Maker Series, a series of education resource packages that aim to empower youth (grades 7-12) through multi-media narratives about individuals making a difference along the Upper St. Lawrence River and beyond. The series is part of a larger project called the Great River Rapport, a collaborative, community engaged ecosystem health report focused on the Upper St. Lawrence River. This project, in partnership with Mohawk Council of Akwesasne, weaves scientific data together with stories, Indigenous perspectives, and photography to communicate 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 making change for the environment and people. Each resource package aims to inspire youth by 1) learning *about* action through a case study and 2) learning *through* action by taking part in an action-oriented learning activity. This presentation will provide an overview of resource packages, how these materials can engage youth with Great Lakes ecosystems and highlight preliminary results from a study that assesses the impact of these resource packages as a support for educators to empower youth as changemakers.

Miranda Devan[1], Scott McNaught[1], Ellen Marsden[2] and Traci Galarowicz[1], [1]Central Michigan University, [2]University of Vermont. **Importance of Zooplankton Abundance to Diet, Growth, and Survival of Larval Coregonines in Laurentian Great Lakes and Lake Champlain.**

Lake Whitefish (*Coregonus clupeaformis)* are culturally, economically, and biologically important to the Laurentian Great Lakes in North America. Lake Whitefish populations have declined over the past two decades, likely because of poor larval survival. Zooplankton are the main food source for larval coregonines, and in recent years Lakes Michigan and Huron have seen a tremendous decline in zooplankton density. The main objective of this study is to determine the degree to which zooplankton abundance affects diet and growth of larval Lake Whitefish. We examined samples collected in 2021 and 2022 from nearshore habitats in the Great Lakes (Superior, Michigan and Huron) and Lake Champlain, a reference site with healthy Lake Whitefish populations. Larval growth rates were estimated using a length-age regression and compared among sites in each year. We used non-metric multidimensional scaling (nMDS) to analyze zooplankton composition and larval diet among sites. We anticipate that larval fish at sites with higher zooplankton abundance will eat more food and grow faster than sites with low zooplankton abundance.

Emilia DiBiasio, Fasong Yuan and Anshula Dhiman, Cleveland State University. **Evaluating oxygen consuming organic matter in the central and eastern basins of Lake Erie using stable carbon isotopes.**

Understanding the fundamental biogeochemical processes leading to the formation of seasonal hypoxia and even anoxia in Lake Erie is required for best management practices. The impact of oxygen-consuming organic matter (OM) is regarded as the predominant contributor to hypoxia, closely linking increases in CO_2, which is part of dissolved inorganic carbon (DIC), in the hypolimnion to the effects of respiration. To investigate this process, water samples were collected

from epilimnion and hypolimnion of central and eastern Lake Erie using the Rosette sampler during the April and August 2023 cruises onboard the R/V Lake Guardian. Average DIC concentrations increased slightly from spring surface waters to summer hypolimnetic waters in the central basin (23.5 ± 1.6 vs 24.4 ± 1.7 mg/L) while the eastern basin experienced negligible seasonal changes in DIC (23.6 ± 0.3 vs 23.6 ± 0.4 mg/L). Decreases from spring surface (0 - 2 m) and summer bottom water $\delta^{13}C_{DIC}$ averages were observed in the central (-1.0 ± 0.2 ‰, -3.4 ± 1.0 ‰) and eastern (-1.3 ± 0.2 ‰, -2.6 ± 0.1 ‰) basins. Using a simple $\delta^{13}C_{DIC}$ binary mixing model, we found that the modeled increases in the average concentrations of DIC from OM respiration were much greater than those observed in the basins. The discrepancies may be attributed to seasonal changes in atmospheric CO_2 exchanges and interbasin carbon transfer and cycling. Further information is needed to clarify the carbon cycle related to oxygen dynamics in the central and eastern basins.

Gregory Dick[1, 2], Paul Den Uyl[1, 2], Colleen Yancey[2], Anders Kiledal[1], Vincent Denef[3], Casey Godwin[2], Subba Rao Chaganti[2], Kelly Goodwin[4, 5], Reagan Errera[6] and Henry Vanderploeg[7], [1]Department of Earth and Environmental Sciences, University of Michigan, [2]Cooperative Institute for Great Lakes Research, University of Michigan, [3]Department of Ecology and Evolutionary Biology, University of Michigan, [4]Atlantic Oceanographic and Meteorological Laboratory, National Oceanic and Atmospheric Administration, [5]National Oceanic and Atmospheric Administration Ocean Exploration, National Oceanic and Atmospheric Administration, [6]National Oceanic and Atmospheric Administration Great Lakes Environmental Research Laboratory, [7]Retired, National Oceanic and Atmospheric Administration Great Lakes Environmental Research Laboratory. **The GLERL/CIGLR Omics Program: Insights and Opportunities.**

Rapidly advancing omics technologies provide powerful new ways to characterize Great Lakes biology. These methods can be used to study harmful algal blooms (HABs), microbial communities, and invasive species, and to understand how these and other aspects of the food web respond to climate change, pollution, and other perturbations. However, omics approaches (genomics, transcriptomics, proteomics, and metabolomics) are limited by bottlenecks due to lack of skilled personnel, standards, computational methods for data analysis and sharing, and benchmarking studies. The NOAA GLERL/CIGLR Omics program addresses these challenges by training the next generation of omics scientists, developing new capacity for data analysis and sharing, generating and integrating omics datasets, and conducting experiments to benchmark and link omics data to biological traits, thus complementing GLERL's strengths in observing systems and food web ecology. Results highlight the potential of omics methods to discover and characterize new and emerging HABs toxins, determine what organisms produce HAB toxins, provide early warning of HAB toxins, understand top-down (mussels, viruses) and bottom-up (nutrients) controls on HABs, and monitor invasive species and larval fish dispersal. The Great Lakes Atlas of Multi-omics Research (GLAMR) provides standardized analysis pipelines, synthesizes Great Lakes omics data with environmental data, and makes omics data available through an accessible website (https://greatlakesomics.org/). These data products and tools provide a foundation for developing new approaches to understand, predict, and manage Great Lakes ecosystems.

Matthew Diebel, Dustin Kincaid and Luke Loken, US Geological Survey. **Factors driving changes in phosphorus flux since 2011 in 24 U.S. Great Lakes tributaries.**

Extensive efforts have been made to reduce phosphorus inputs to the Great Lakes, yet tracking progress remains a challenge. Water quality trend analysis with Weighted Regressions on Time, Discharge, and Season (WRTDS) can remove the influence of discharge variability on concentration and flux estimates through flow-normalization. The results provide a view of

underlying trends that can be used to infer watershed management effectiveness. WRTDS was used to evaluate the cause of changes in flow-normalized phosphorus fluxes in 24 U.S. Great Lakes tributaries from 2011-2020. In particular, we evaluated phosphorus concentration-discharge relationships, seasonal patterns and changes in total and dissolved phosphorus flux, and changes in point-source phosphorus inputs. Flow-normalized phosphorus flux decreased in all watersheds with low phosphorus yield (< 50 kg km^{-2} yr^{-1}) and increasing mean annual discharge over the study period, suggesting the development of supply limitation. Seasonal fluxes of both total and dissolved phosphorus were generally highest in spring, but this pattern was more pronounced for total phosphorus. In all but two tributaries, percent changes in total phosphorus were more negative than percent changes in dissolved phosphorus, indicating potential increases in phosphorus bioavailability. These results may help guide ongoing phosphorus reduction efforts in Great Lakes tributaries.

Zachary Diloreto and Maria Dittrich, University of Toronto. **Calcinated Eggshell and Woodchip Bioreactors - Upcycling Waste Products for Cost-Effective P Removal in A Circular Economy.**

One of the challenges towards a sustainable economy in respect to phosphorus (P) is creating an open, efficient cycle for P that has little impact on the natural environment. Waste eggshells from the liquid egg industry have potential as a P removing substrate and represent a component in achieving a circular P economy. Waste eggshells can be calcinated, or converted to calcium oxide, which increases their porosity as well as surface area and promotes adsorption and precipitation of PO_4 from solution. This material after interacting with agricultural runoff can be reused as a potential fertilizer. To further develop this technology, we performed batch removal and adsorption experiments to characterize calcined eggshells as a reactive surface. Additionally, woodchips were examined as a substrate additive to impact nitrogen removal by stimulating denitrifying microbes. Initial results showed that eggshells removed up to 80% of dissolved P with as little as 2-3 total weight % in only 8 hours. This was then upscaled into a bench-scale system where additional water quality parameters were tested and geochemical modelling implemented to assess potential environmental impacts. Results from bench-scale tests were used to design and successfully implement 3-field scale units able to remove >70% of PO_4 without negatively impacting key water quality parameters.

Rebeccah DiPuccio[1], John Farver[1], Jeffrey Miner[2], Michael Tappa[3] and Annie Bauer[3], [1]Department of Geology, Bowling Green State University, [2]Department of Biology, Bowling Green State University, [3]Department of Geoscience, University of Wisconsin-Madison. **Combining 87Sr/86Sr and Sr:Ca Data to Determine Natal Rivers of Grass Carp in Lake Erie.**

Grass carp are an invasive species that pose great concern for the Great Lakes especially the western basin of Lake Erie. Previous efforts to determine the natal rivers of grass carp captured in Lake Erie and its tributaries based on the Sr:Ca microchemistry of their otoliths yielded limited success due to overlap of the Sr:Ca values in the Sandusky and Maumee Rivers (the two most likely rivers for successful spawning) under different flow conditions, and uncertainty in the water:otolith Sr:Ca partition coefficient (Whitledge et al., 2021). This study employed strontium isotopes (87Sr/86Sr) in combination with Sr:Ca elemental data to differentiate the Sandusky and Maumee Rivers as natal sites. The 87Sr/86Sr values of water from the Sandusky and Maumee Rivers were determined over a range of flow conditions and 87Sr/86Sr of the otoliths were measured both in the core (natal) region and in the edge (migration) regions. The otolith core results indicate three clusters with 12 of the 12 fish previously designated as Sandusky River origin and 6 of the 9 designated as

Maumee/Sandusky River origin are in the Sandusky River/Bay cluster. Two designated as Maumee/Sandusky River are in the Maumee River cluster, and the remaining fish designated Maumee/Sandusky River is in the Detroit River/Lake Erie cluster. Although the Sandusky River/Bay is the dominant natal river system, otolith edge results indicate grass carp migrate throughout the Lake Erie western basin.

Maria Dittrich[1], Zachary Diloreto[1], Khoren Avetisyan[1], Sara Zaferani[1], Lyubov Burlakova[2] and Alexander Karatayev[2], [1]University of Toronto, [2]SUNY, Buffalo State University. **Geochemical heterogeneity at the sediment-water interface is linked to a presence of freshwater mussels in Lake Ontario.**

The benthic communities of Lake Ontario have been studied intensively over the last six decades. The invasion of dreissenid is a main feature of the Lake Ontario benthic community, dominated by quagga mussels, it is one of the major drivers of observed changes over the last half century. However, it remains unclear how sediment vertical zonation is linked to mussels' spatial distribution or mussels' impact on the sediment-water interface. In this aspect our study aims to investigate the sediment water interface and link biogeochemical conditions to freshwater mussel abundances. To achieve this sediment cores were examined in conjunction with depth-profiles of organic carbon, nutrients and geochemistry. Sediment cores were collected at various depths from off-shore and on-shore stations at the 35m, 51.3m, 106m, 152m and 211m with varying distributions of mussels. The data collected from depth-profiles and cores were coupled with geochemical data to create simple models using AQUSIM. These models were extrapolated and used to calculate rates of carbon mineralization and nutrient retention. Morphological examination as well as elemental composition of samples was examined through a combination of scanning electron microscopy (SEM), and energy-dispersive X-ray spectra (EDS). Morphological characterization was performed in conjunction with mineralogical characterization using X-ray diffraction (XRD) to validate geochemical modelling. Additionally, to evaluate the impact of mussels on benthic biogeochemistry, microbial community analysis was conducted using amplicon sequencing on short cores from all sampling stations.

Sonja Drosdowech[1], Marcia Chiasson[2], David Huyben[3] and Neil Rooney[4], [1]School of Environmental Sciences, University of Guelph, [2]Ontario Aquaculture Research Centre, University of Guelph, [3]Department of Animal Biosciences, University of Guelph, [4]University of Guelph, School of Environmental Sciences. **Replacing fishmeal with insect meal reduces waste phosphorus in farmed rainbow trout.**

The inclusion of fishmeal and fish oil as primary protein sources in feeds for farmed fish is not ecologically sustainable and alternative protein sources need to be evaluated. The aim of this study was to determine the effect of defatted black soldier fly larvae (Hermetia illucens), adult cricket (Gryllodes sigillatus) and superworm (Zophobas morio) on the growth and nutrient assimilation for juvenile rainbow trout (Oncorhynchus mykiss). Fish were fed one of four dietary treatments: a control diet with 20% fishmeal, and three experimental diets containing either 15% defatted black soldier fly meal, full-fat adult cricket meal or full-fat superworm meal, where each insect meal partially replaced fishmeal and fish oil. No significant differences were detected among the diets for growth performance indicators or body indices. No significant effects among the diets were found on whole-body carcass saturated fatty acids (SFAs), monounsaturated fatty acids (MUFAs), polyunsaturated fatty acids (PUFAs) n-3 and n-6. In contrast, lauric acid and myristic acid were significantly higher in fish fed black soldier fly diet. Importantly, the apparent digestibility of phosphorous was significantly improved for all insect diets compared to the control. These results

indicate that insect meals can partially replace fishmeal and fish oil in diets for rainbow trout without compromising growth performance while also reducing phosphorous in fish waste.

Ken Drouillard[1], Satyendra Bhavsar[2], April White[3] and Ted Briggs[2], [1]University of Windsor, [2]Ministry of Environment, Conservation and Parks, [3]Environment and Climate Change Canada.
Assessment of fish consumption restrictions in Canadian portions of the Detroit River Area of Concern.

Fish consumption restrictions were assessed for Canadian waters of the Detroit River Area of Concern (AOC) by adopting a tiered assessment framework. Tiers 1 to 3 evidence lines were compiled for indicators: brown bullhead, largemouth bass and walleye as specified by the delisting criteria in the Stage 2 RAP report. Tier 1 compared fish consumption restrictions in indicators against an unrestricted consumption criteria of 8 meals/month. Brown bullhead passed the criteria but the other two fish failed. Tier 2 compared whether restrictions in the AOC were more stringent compared to Great Lakes reference areas. This tier failed for largemouth bass and walleye. Tier 3 compiled multiple evidence lines related to fish chemistry and fish movements and interpreted outcomes by a weight of evidence (WOE) decision matrix. Largemouth bass passed but walleye failed. Tier 4 compiled evidence lines concerning spatial and temporal trends of environmental contamination in the AOC to evaluate if additional restoration actions in Canadian waters would further reduce fish consumption restrictions. The WOE interpretation for Tier 4 indicated a lack of evidence for local sources (i.e. within Canadian waters of the AOC) contributing to excess mercury or PCB bioaccumulation in fish, but recognized that planned sediment restoration activities for U.S. portions of the AOC are likely to benefit Canadian caught fish. Based on these outcomes, it is recommended that BUI #1 be re-assessed as not impaired.

Molly Duhamel[1], Ashley Braucksieck[2], Robert Furlong[2], Jon Rife[1], Lauren Eggenton[2], Brady Swartz[1], Kevin O'Shea[3], Kara Tarallo[4], Christina Kuchle[4], Lauren Kinsman-Costello[5] and W. Robert Midden[6], [1]Otsego Junior High School, [2]Otsego High School, [3]Otsego Local Schools, [4]Ohio Department of Natural Resources, [5]Kent State University, [6]Bowling Green State University. **A wetlands project designed for K-12 students to engage in citizen science.**

The State of Ohio is funding the H2Ohio program which includes creating and restoring more than 7,000 hectares of wetlands as one means of reducing phosphorus transport into destination water bodies to reduce Harmful Algal Blooms. One project across the street from a public school district has been designed as a living laboratory to enable student participation in citizen science. Community members, conservation partners, and H2Ohio agreed this is an excellent opportunity to create wetlands to improve water quality while providing powerful hands-on/minds-on education opportunities. H2Ohio values student involvement in these restoration projects because they are the next generation that will be responsible for the use and management of our natural resources. Goals set by teachers for their students' participation include instilling values of respect and responsible behavior towards the environment, emphasizing environmental ethics, conservation and stewardship. Junior high and high school students are generating data that will be used by the professional scientists who are monitoring the effectiveness of these wetlands. Activities include assessing wetland benefit by comparing water quality of wetlands pools to the adjacent creek that serves as the watershed collection point, evaluating biodiversity of the different ecological regimes using Simpson's Biodiversity Index, as well as analyzing their data and presenting their research reports to stakeholders such as the Toledo Metropolitan Area Council of Governments. Teachers and students will present this with H2Ohio scientists and staff.

Alexander Duncan, Centre for Indigenous Fisheries, University of British Columbia. **Listening to rightsholders: Bimiizii (sea lamprey) in the Great Lakes.**

The control of sea lamprey serves a critical role in the management of fisheries in the Laurentian Great Lakes, successfully suppressing populations over the last several decades. During this time however, there has been inconsistent recognition and consideration of First Nations (CAN) and Tribal (US) interests and inherent rights. 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. Novel research 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 findings and future directions.

Erin Dunlop[1, 2] and Issac Hébert[1], [1]Ontario Ministry of Natural Resources and Forestry, [2]Environmental and Life Sciences Graduate Program, Trent University. **Early life history dynamics of coregonines in lakes Huron and Simcoe.**

Coregonines, including cisco (*Coregonus artedi*) and lake whitefish (*C. clupeaformis*), play important ecological roles in the food web and support valuable commercial, subsistence, and recreational fisheries in lakes throughout their species ranges. In lakes Huron and Simcoe, both species experience a myriad of stressors, including invasive species, climate change, and habitat alteration that impact population dynamics and fisheries sustainability. Despite common stressors, coregonine population dynamics show different trends between species and lakes, for example with lake whitefish population abundance and recruitment declining precipitously in Lake Huron but having more stability in Lake Simcoe. To understand how processes affecting early life contribute to population dynamics of coregonines in these different systems, we compared the year-to-year variability in larval fish emergence, abundance, growth, and spatial distribution between study sites in lakes Huron and Simcoe. We furthermore measured zooplankton biomass to examine the role of food availability in the survival and growth of larval fish. Lake Simcoe, where excessive nutrient loading is a concern and coregonine populations are recovering, was had higher levels of zooplankton biomass during the spring larval period. By contrast, the Fishing Islands region in Lake Huron had relatively lower zooplankton biomass but higher larval lake whitefish densities than other areas in Lake Huron and in Lake Simcoe. These findings have implications for recruitment to the juvenile life stage and for the future sustainability of these valuable populations.

E

Hamed Ebrahimi[1], Leon Boegman[1] and Reza Valipour[2], [1]Queen's University, Smith Faculty of Engineering and Applied Science, Department of Civil Engineering, Kingston, Ontario, Canada, [2]Environment and Climate Change Canada, Water Science and Technology, Canada Centre for Inland Waters, Burlington, Ontario, Canada. **Automated calibration of a three-dimensional hydrodynamic and surface water quality model using machine learning.**

Process-based coupled hydrodynamic-biogeochemical model are used to simulate surface water quality issues in lakes. In Lake Erie, these include eutrophication, invasive species impacts, harmful algal blooms, hypoxia, and the impacts of climate change. Despite efforts by skilled lake modelers, calibration of these models remains subjective and challenging. These challenges result from the laborious and computational demanding simulations associated with trivial tuning of numerous interconnected model parameters to validate models against numerous field observations.

The combination of these factors, along with uncertainties arising from model grid-induced aliasing and uncertainty in boundary conditions (e.g., meteorological forcing and riverine inputs), results in subjective and under-calibrated representations of the simulated physical-biogeochemical processes in lakes. In this study, we incorporated the XGBoost machine learning algorithm to impartially calibrate the Aquatic Ecosystem Model 3D for Lake Erie, assess model sensitivity to calibration parameters and uncertainty introduced by boundary forcing and grid resolution. This provides the groundwork for efficient calibration with minimal uncertainty to develop fully automated water quality models for the Great Lakes and elsewhere.

Alyssa Eck[1], Andrew McQueen[1], Catherine Thomas[1], Afrachanna Butler[1], Todd Slack[1], Gregory Mausolf[2] and Jeffrey Bednar[3], [1]US Army Engineer Research and Development Center, [2]US Army Corps of Engineers - Detroit District, [3]Macomb County Public Works. **Distribution, Environmental Drivers and Risks of Microseira wollei.**

Noxious growths of the cyanobacterium, *Microseira wollei* have recently increased within the western portion of Lake St. Clair, MI. However, there are uncertainties related to historical spatial distribution of *M. wollei* within Lake St. Clair and throughout North America, environmental drivers stimulating blooms, and potential human and ecological health risks. Therefore, to address these uncertainties, a strategic literature review was performed and information gained from this review will inform future management. Occurrences of *M. wollei in* North America have been reported from Canada to Florida, with anecdotal observations fitting the general description of *M. wollei* within Lake St. Clair dating back 30yrs. Based on laboratory and field data, the environmental tolerances of *M. wollei* are relatively broad. *M. wollei* can proliferate with a pH from 7 to 9, specific conductance from 250 to 1,200µS/cm, light intensities from 11 to 100µmol photons $m^{-2}s^{-1}$, temperatures from 20 to 35°C, and nutrient concentration ranging from 0.6mg/L NO_3-N to 83mg/L NO_3-N and 0.55mg/L PO_4 -P to 5.5mg/L PO_4-P. Environmental drivers may be site-specific and specific to the *M. wollei* population. Human health risks from *M. wollei* may originate from toxins and disinfection byproducts. *M. wollei* has the potential to produce a range of toxins; however, the most prevalent toxins are saxitoxins, a group of neurotoxins. The potential human health risks associated with toxin production of *M. wollei* highlight the need for adaptive management.

Devin Edge[1], Amber McRae[1], Sophia Nelson[1], Hunter Peterson[1], Riley Brunner[1], Kathryn Schreiner[2], Chan Lan Chun[1], Euan Reavie[1], Christopher Filstrup[1] and Bridget Ulrich[1], [1]Natural Resources Research Institute, University of Minnesota Duluth, [2]Large Lakes Observatory, University of Minnesota Duluth. **New perspectives on spatial and temporal distributions of legacy and emerging contaminants in Lake Superior.**

Many legacy and emerging organic contaminants are resistant to environmental degradation and are known to accumulate in sediments. We aim to advance understanding of relationships between environmental distributions of persistent bioaccumulative toxic contaminants (PBTs) and overall ecosystem health in the Great Lakes, as part of the US EPA's Great Lakes Sediment Surveillance Program. This presentation will focus on the spatial and temporal trends for legacy and emerging organic contaminants in Lake Superior. 90 sediment samples (30 surface sediments and 60 samples from 3 sediment core profiles) were collected in 2021 from the R/V Lake Guardian, and 138 legacy and emerging contaminants (including polychlorinated biphenyls, polybrominated diphenyl ethers, and novel halogenated flame retardants) were analyzed in the sediments via gas chromatography triple quadruple mass spectrometry (GC QQQ-MS). Comparison of the new sediment core data with historical data from the same sites show that concentrations change over

time for several analytes. These findings provide important context for interpretation of historical sediment data in conjunction with data from contemporary ecological surveys.

Thomas Edge[1], Rachel Boyd[2], Jan Ciborowski[3], Jerome Comte[2], Ngan Diep[4], Alice Dove[2], Phoenix Shum[2], Zachery Staley[2], Janis Thomas[4], Linet Watson[2], Susan Watson[2], Arthur Zastepa[2] and Sophie Crevecoeur[2], [1]McMaster University, [2]Environment and Climate Change Canada, [3]University of Windsor, [4]Ontario Ministry of Environment, Conservation, and Parks. **Microbial source tracking of fecal pollution (human and ruminant) and nutrients along the Thames River to Lake Erie corridor, Ontario.**

Applications of molecular and genomics technologies offer many opportunities to enhance water quality surveillance. As part of the Canadian federal government's Ecobiomics Project to advance molecular and genomics technologies, a microbial source tracking study was conducted to identify sources of fecal pollution and nutrients from the Thames River to Lake Erie corridor. A biweekly sampling program collected 2,258 water samples between 2016-2018 from the Thames River, and nearshore waters of Lake St Clair, Detroit River, and western basin of Lake Erie. Water samples were analyzed for nutrients, *E. coli*, and host-specific human (HF183) and ruminant (Rum2Bac) microbial DNA markers by digital PCR. While *E. coli* data could identify hot spots and peak times of fecal pollution, they could not be used alone to assess sources of fecal pollution and nutrients. The human and ruminant DNA markers were detected at varying concentrations at all sampling sites, and their use enabled discrimination between sources of human and ruminant (e.g. cattle) fecal pollution, better interpretation of *E. coli* and nutrients data, and testing of assumptions about sources of fecal pollution and nutrients. Ecobiomics Project applications of digital PCR (this study), and metabarcoding of cyanobacteria (Crevecoeur et al. 2023. Frontiers in Micro.) along the Thames River-Lake Erie corridor, demonstrate how molecular and genomics technologies can enhance water quality surveillance, and advance assessment of human and ecosystem health risks.

Abel Egbemhenghe, Texas Tech University. **Chemical Analysis of Essential Trace Elements in Wastewater Samples Collected from Four Different Mines.**

Mine water contains trace heavy metals which are some essential trace elements in high concentrations causing the pollution of nearby water bodies, related ground waters and soils degradation. The aim of the study is to identify and quantify the essential trace elements present in the different mine water samples and their level of toxicity. Digestion technique was employed to pretreat the mine wastewater before analysis. Physicochemical analysis was conducted for pH, electrical conductivity (EC), total dissolved solids (TDS), and salinity. The samples collected from four different locations are Sample A (Gold mine), Sample B (Copper mine), Sample C (Iron mine), Sample D (Tin mine). The raw or untreated mine water samples were analyzed using inductively coupled plasma optical emission spectroscopy (ICPOES). The results showed the essential trace elements present in all the mine water samples are Mn, Cu, Fe and Zn. Cu is highly concentrated in copper (73.87 mg/L) and tin (2.09 mg/L) mine water while Fe is dominant in water samples collected from gold (7.19 mg/L) and iron (13.12 mg/L) mines. In conclusion, the essential trace elements Mn, Cu, and Fe present in all the mines are very high and can be harmful to human life in the environment but the concentrations of Zn in the entire mine water samples are within the permissible level of standard drinking water and hence it can pose no threat to human life.

Lindsie Egedy[1], Jonathan Doubek[2], Kevin Kapuscinski[2], Simon Freeman[2], Erin Dunlop[3], Jose Bonilla-Gomez[4], Ralph Tingley[1] and Cory Brant[1], [1]U.S. Geological Survey Great Lakes Science Center, [2]Lake Superior State University, [3]Ontario Ministry of Natural Resources and Forestry, [4]U.S.

Fish and Wildlife Service. **Post-larval juvenile lake whitefish spatial distribution in Lake Huron, 2022.**

During the 2022 Lake Huron CSMI year, the U.S. Geological Survey and Lake Superior State University partnered to sample post-larval and juvenile Lake Whitefish using bag seines in the North Channel and Southern Lake Huron in effort to evaluate differences in abundance, growth, and diet across areas of contrasting lower trophic level productivity. Here we present these data with additional 2022 sampling efforts from the U.S. Fish and Wildlife Service and the Ontario Ministry of Natural Resources and Forestry to visualize differences in abundance across the lake. Sample sites included multiple locations along the northern, central, and southern shorelines of Lake Huron. Larval lake whitefish were confirmed to be present at all sites in surface tows earlier in the season. Juvenile lake whitefish were captured in Saginaw Bay as well as other regions of the central and northern basin in bag seines later that summer. Interestingly, we found no juvenile coregonines in bag seine catches at the southern sites (Harbor Beach, Port Sanilac, Lexington, and Port Huron). It's notable that no post-larvae juveniles were captured at southern sites. Further analyses (i.e., diet, growth, CPUE comparisons) may reveal evidence of recruitment constraints for lake whitefish and can inform where future sampling or long-term monitoring may be valuable.

Festus Eghe, University of Benin. **Developing a Sediment-Specific Multimetric Index (SMMI) for Assessing the Effects of Fine Sediments in the Ogba River and its Tributaries, Edo State, Nigeria.**

Sedimentation of freshwater systems, including rivers and lakes, is one of the leading causes of water quality deterioration. The Ogba River, Edo State, Nigeria, is vulnerable to elevated sediment impact due to dispersive soils that are easily erodible. We lack biomonitoring-specific tools for monitoring the effects of sediment stress in Nigeria, hindering the efforts of water resource managers to make informed decisions and policy formulations to manage sediment effects. In this study, the taxonomy approach was used to assess the responses of macroinvertebrates to sediments in the Ogba River, Delta State. Macroinvertebrates were sampled seasonally from 2016 to 2018 from eight sites, using the South African Scoring System version 5 as a collecting protocol. We selected sites to represent a gradient of sediment influence from the highly impacted to moderate and the least affected, referred to as the control sites. A multimetric sediment index (SMMI) was developed to monitor the impact of fine sediments on macroinvertebrate assemblages of this river. The developed SMMI could distinguish between highly impacted vs moderately impacted during the wet season and responded to seasonality. The newly developed SMMI indicated that the effects of sediments were more harmful in the wet than in the dry season. Thus, the SMMI performed well in distinguishing highly sedimented sites from less sedimented sites. We hope that SMMI will contribute towards developing an effective sediment monitoring index for the country.

Jane Elder, Great Lakes Ecoregion Network. **Great Lakes sustainability requires social, economic, and institutional transformation.**

More than fifty years after the first Great Lakes Water Quality Agreement, the Great Lakes ecoregion continues to carry the burden of legacy pollution, invasive species, algal blooms, and rust belt recovery, while also grappling with the twin crises of climate change and biodiversity loss. Incremental progress under current policy and institutional frameworks is laudable, but insufficient to achieve a healthy system affected by so many stressors and their pace and scale. Achieving sustainable resilience in human and ecological communities requires new collaborative approaches and new policy-making frameworks in a world that urgently needs healthy and sufficient food, safe and abundant water, as well as robust natural systems able to withstand climate disruption, soil

depletion, species extinction and other global threats. Eroding trust in public institutions and science exacerbates the challenge. Our collective health and well-being depends on re-imagining our relationship with the lakes, the land, and our communities, and envisioning a new approach informed by deep traditional knowledge, community cohesion, and visionary leaders. How can science help, and how can *we help science* in this transformation? Elder will discuss these and related findings from her new book (MSU Press), *Wilderness, Water & Rust*, relevant to the session topic.

Ashley Elgin[1], Steve Pothoven[1], Alexander Karatayev[2], Lyubov Burlakova[2] and Thomas Nalepa[3], [1]National Oceanic and Atmospheric Administration Great Lakes Environmental Research Laboratory, [2]Great Lakes Center, Buffalo State University, [3]National Oceanic and Atmospheric Administration Great Lakes Environmental Research Laboratory, Retired. **Catching history in a Ponar: Documenting decades of dreissenid mussel invasion in Lake Michigan.**

The introductions of invasive dreissenid mussels (zebra mussels, *Dreissena polymorpha* and quagga mussels, *D. rostriformis bugensis*) have had profound impacts throughout the Laurentian Great Lakes basin. A benthic monitoring program established by the NOAA Great Lakes Environmental Research Laboratory in the early 1980's documented the status of bottom-dwelling organisms in Lake Michigan following decades of phosphorus abatement. These baseline surveys proved to be especially valuable given the introduction of invasive dreissenid mussels that occurred in the decade to follow. Monitoring efforts and approaches have expanded over time to capture this dynamic invasion. Our talk will describe the population trajectories of dreissenid mussels in Lake Michigan over several decades and summarize the resulting ecosystem effects. We will also incorporate findings from complementary mussel veliger, growth, and reproduction studies to offer insights into future trends for dreissenid mussels in Lake Michigan.

Ahmed Elsayed[1], Jana Levison[1], Andrew Binns[1], Marie Larocque[2] and Pradeep Goel[3], [1]School of Engineering, Morwick G360 Groundwater Research Institute, University of Guelph, Guelph, Ontario, Canada, [2]Department of Earth and Atmospheric Sciences, Université du Québec à Montréal, Montréal, Québec, Canada, [3]Ministry of the Environment, Conservation and Parks (MECP), Etobicoke, Ontario, Canada. **Application of machine learning algorithms for quantification of nutrient transport in two distinct agricultural settings.**

Agricultural fields are significant non-point sources of releasing nutrients (e.g., nitrogen and phosphorus) 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. In addition, multiple factors affect nutrient transport in agricultural areas such as soil, climate, and field conditions. Thus, quantification and understanding of nutrient transport in water resources is essential. Machine learning (ML) algorithms can be implemented as an effective approach to better understand 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, multiple families of classification and regression ML algorithms were implemented on two datasets obtained from two distinct agricultural watersheds in the Great Lakes Basin in Ontario, Canada, with clay plain (i.e., Upper Parkhill) and sand plain (i.e., Lower Whitemans Creek) settings, to characterize nutrient concentrations in surface water and groundwater. The input variables of ML models included climatological (e.g., precipitation), hydrological (e.g., stream 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 and protect groundwater and surface water quality in agricultural watersheds.

Reagan Errera[1], Casey Godwin[2], Mark Rowe[1], Craig Stow[1], Steve Ruberg[1], Rick Stumpf[3], Greg Doucette[3], Gregory Dick[2], Andrea Vander Woude[1], Lauren Marshall[1], Danna Palladino[1], Duane Gossiaux[1], Ashely Burtner[1], Christina Mikulski[3] and Henry Vanderploeg[1], [1]NOAA GLERL, [2]CIGLR, [3]NOAA NCCOS. **Advancements in HAB research since the Toledo Water Crisis: a decade of GLERL science.**

In August 2014, a toxic cyanobacteria bloom in western Lake Erie triggered a crisis for half a million residents around Toledo, OH, becoming the first major occurrence of harmful algal bloom (HAB) shutting down US drinking water supply. NOAA GLERL and other partners have been key scientific contributors to the advancement of our understanding of cyanobacteria HABs (cHABs) via the development of monitoring networks throughout the Great Lakes, testing and developing emerging technologies, and creating predictive models. We have developed a better understanding of bloom dynamics through weekly ecological monitoring, which supports NOAA forecasts and end-users, real-time water quality buoys that provide context for research and awareness for resource managers, Environmental Sample Processors (ESP), hyperspectral imaging, and the integration of these data into our modeling efforts. Through implementation of 'omics techniques, we have been able to identify key cyanobacteria strains, track community and microcystin congener shifts, and provide near real-time toxin concentrations to stakeholders. Concomitant laboratory experiments have identified important environmental factors that influence the blooms' dynamics. This presentation will describe advances in our scientific understanding of bloom dynamics in Lake Erie, over the past decade and how GLERL and its partners provide essential information to the scientific community, managers, and public stakeholders.

Hana Esber, Michael Back, Kenneth Anderson, Bishwodeep Adhikari, Raissa Mendonca and Lauren Kinsman-Costello, Kent State University. **Wetland surface water extent at St. Joseph's River Restoration Project using PyGEE- SWToolbox.**

Wetlands are areas with variable flooding throughout the year. Measuring the extent of surface water flooding can provide information about the wetland's features and structure. Wetland inundation regimes could affect the nutrient cycling and how development is planned. We investigated wetland inundation and asked: 1) How does a recently restored wetland flood throughout the typical year? 2) What is the most accurate water index /threshold to use on new wetland projects? We estimated inundation timing and extent at the H2Ohio St. Joseph's River Restoration Project (SJRE) using a Python-Google Earth Engine Surface Water Analysis Toolbox (PyGEE-SWToolbox). The SJRE is being intensively monitored by the H2Ohio Wetland Monitoring Program, which will support validation of remotely sensed inundation data. We ran several analyses with different threshold markers and settings and used the PyGEE-SWToolbox water hydrograph tool to identify peak surface water extent events and generate comparative raster images to map inundation patterns. Results indicate that SJRE not only floods from the adjacent St. Joseph's River, but also from the tile drains, peak surface water inundation extent occurs during winter months, and that ice/snow reflection might be a factor influencing the water extent tool. This work can lead to a greater understanding of how restored wetlands hold surface water and handle flood events.

Peter Esselman[1], Shadi Moradi[2], Anthony Geglio[1] and Joseph Geisz[2], [1]US Geological Survey Great Lakes Science Center, [2]Michigan Technological University Great Lakes Research Center. **A new status and trends dataset for round goby lake-wide abundances using robots carrying cameras.**

Invasive round goby (*Neogobius melanostomus*) have become an important prey item for Great Lakes predators and can have negative impacts on native species populations. Traditional methods for round goby monitoring, such as bottom trawling, are widely considered to underestimate round goby abundances due to their inefficiency in habitats preferred by round goby during the sampling season (e.g., shallow, rocky habitats). Here we present the results of a six-year effort to develop and validate a new substrate-agnostic method to survey round goby in clear-water lake environments using autonomous underwater vehicles (AUVs) carrying down-looking cameras. We present a machine vision pipeline that automatically detects and estimates round goby biomass densities and local substrate conditions in tens of thousands of images with good accuracy, repeatability, and computational efficiency. We applied the pipeline to estimate lake-wide abundances of round goby in Lake Michigan (2020 - 2023), Lake Huron (2021 - 2023) and Lake Ontario (2022 - 2023), highlighting the cross-lake comparability of biomass estimates. Our results show that round goby abundances may have been underestimated by at least an order of magnitude in historic bottom trawl assessments. We suggest that the data presented may serve as an excellent foundation for continued status and trends monitoring using autonomous vehicles, and point to opportunities to simultaneously enhance monitoring of dreissenid mussels, nuisance algae, substrates and other lakebed features.

Peter Euclide, Illinois-Indiana Sea Grant | Purdue University. **What the Pareto principal can tell us about the Lake Michigan Salmonid fishery.**

The pareto principle predicts that 80% of productivity results from 20% of effort. We apply this principle to a 30-year dataset of reported salmonid catch from charter fishers in Lake Michigan to test the hypothesis that catch results from a disproportionately small number of expeditions, locations, months, and years. By comparing total harvest numbers of each species combined and separately, we find that concordance to the Pareto Principal differs among species. In all species, there is strong spatial bias whereby 20% of 10X10 grids represent >85% of raw catch for each of the five species investigated. The degree of this spatial bias differs, whereby 96% of coho comes from just 20% of grids while both rainbow trout and lake trout are caught somewhat more widely. Certain grids consistently contain high effort and catch (i.e., in the top 20% of the distribution) for all 5 species but other grids represent high catch for only a single species suggesting potential differences in niche space among species. While results indicate that spatial variance in catch is highly localized, the cause of this localization is likely a combination of angler and fish behavior.

Mary Anne Evans[1], Megan McCusker[2] and Todd Howell[3], [1]U.S. Geological Survey, Great Lakes Science Center, [2]Environment and Climate Change Canada, Water Quality Monitoring and Surveillance Division, [3]Ontario Ministry of the Environment, Conservation and Parks, Environmental Monitoring and Reporting Branch. **Cladophora community assessments: Shared Lakes, Shared Data.**

Due to nuisance conditions caused by excessive algal washup, benthic algal *Cladophora* community assessment is conducted to support management plans under the Great Lakes Water Quality Agreement. Sentinel site assessments of the benthic algal community have been conducted in the Canadian and US waters of the Great Lakes to assess abundance, growth, temporal trends, and drivers of growth. Assessments in Canadian waters began in Lake Erie in 2012, expanding to Lake Ontario in 2017. Assessments in the US waters of Lakes Erie, Ontario, Huron, and Michigan began in 2018 using complementary methods. Preliminary analysis of overlapping years in the Lake Erie data set suggest comparability in biomass measurements and no trend through time. Historically, nuisance growth has been controlled by local nutrient reductions. However, large scale

disturbance of Great Lakes nutrient cycling by invasive dreissenid mussels has cast into doubt the continued effectiveness of nutrient limitation as a tool for *Cladophora* community control. Filter feeding and excretion by Dreissenid mussels concentrates available nutrients in near bottom water; increases light penetration, increasing the potential depth distribution of benthic algae; and increases the surface area of hard substrate for algal attachment. We will explore comparative analysis of drivers of growth and biomass between US and Canadian waters as well as among lakes to evaluate the potential effectiveness of nutrient based *Cladophora* community control in the current ecosystem.

Thomas Evans[1], Lars Rudstam[1], Mark DuFour[2], Suresh Sethi[3], Daniel Yule[4], S. Dale Hanson[5], Benjamin Turschak[6], David Warner[7], Steven Farha[7], Timothy O'Brien[7], Jeremy Holden[8], Kevin McDonnell[9], Steven Senczyszyn[10], Andrew Barnard[11] and Peter Esselman[7], [1]Cornell University, Dept. Natural Resources and the Environment, [2]U.S. Geological Survey, Great Lakes Science Center, Lake Erie Biological Station, [3]Brooklyn College, School of Natural and Behavioral Sciences, [4]U.S. Geological Survey, Lake Superior Biological Station, [5]U.S. Fish and Wildlife Service, Green Bay Fish and Wildlife Conservation Office, [6]Michigan Department of Natural Resources, Charlevoix Fisheries Research Station, [7]U.S. Geological Survey, Great Lakes Science Center, [8]Ontario Ministry of Natural Resources and Forestry, Lake Ontario Management Unit, [9]Alpena Fish and Wildlife Conservation Office, US Fish and Wildlife Service, [10]Department of Civil and Environmental Engineering, Michigan Technological University, [11]Graduate Program in Acoustics, Penn State.
Assessing fish avoidance to motorized acoustic survey vessels using quiet uncrewed surface vessels in Lake Erie.

Acoustic surveys provide an opportunity to assess spatially extensive stocks and are widely employed for prey fish surveys in the Great Lakes. However, a major assumption of these surveys is that fish exhibit normal behavior, i.e., they do not avoid or respond to approaching vessels which would bias survey estimates. If fish detect and avoid vessels, it is likely in response to engine noise. Quiet uncrewed platforms are becoming increasingly available and offer the opportunity to explore bias in fisheries surveys. A quiet uncrewed surface vehicle (USV) operated by Saildrone was equipped with a 120 kHz Simrad EK80 transducer and deployed in Lake Erie during the summer of 2023; these USVs were overtaken by four motorized vessels. We evaluated if 2 km transects measured by motorized vessel and USV showed similar acoustic density and behavioral responses. We also explored whether acoustic responses changed as motorized vessels approached the USV. This work is compared to similar studies conducted in 2021 and 2022 in Lakes Huron, Michigan, and Superior. Findings from this work will inform interpretation of acoustic data in the Great Lakes and provide the largest scale testing of fish avoidance during acoustic surveys to date.

F

Mona Farhani, Alice Grgicak-Mannion, Paul Weidman and Kenneth Drouillard, University of Windsor. **Using deep learning Neural Network model to interpolate sediment PCBs in the Detroit River.**

Downscaling and interpolation of disparate sediment chemistry datasets in complex, dynamic systems such as Great Lakes connecting channels requires advanced machine learning tools such as Artificial Neural Networks (ANNs). Such networks can be highly effective at handling non-linear relationships between diverse sets of user-generated inputs. In this study, ANNs were employed to interpolate high resolution maps of sediment PCBs in the Detroit River Area of Concern. We compiled sediment PCB concentration data from multiple surveys from University of

Windsor and Michigan EAGLE/EPA to facilitate model training. ANNs were produced based on a large series of initial model inputs generated across different positional descriptors, physical characteristics, and chemical characteristics. Model parsimony was achieved by comparing model predictive performance after progressive removal of model inputs to balance predictive power against model complexity. Model validation was further evaluated by comparing model predictions against independent reserved validation data. Predictive performance of the optimized ANN model was then compared against classic GIS approaches such as kriging. Downscaling exercises were used to generate high resolution spatial maps of PCBs at a scale of 100 m x 100 m grid cells superimposed across the entire AOC boundary with particular in reference to previously designated sediment restoration zones identified by Michigan EAGLE/EPA. The maps have utility for generating mass balance estimates to evaluate sediment restoration effectiveness or to evaluate potential biological impacts related to sediment contamination.

Christopher Farrow[1], Loong-Tak Lim[1], Todd Morris[2] and Josef Ackerman[1], [1]University of Guelph, [2]Fisheries and Oceans Canada. **Size matters: Effects of propagule size on dispersal in the Speed River, ON.**

Biologically important particles such as DNA, bacteria, eggs, and larvae span orders of magnitude in size (e.g., 10^{-6} - 10^{-1} m) and are transported downstream in rivers across a broad range of distances (e.g., 10^{0} - 10^{4} m). We studied the effects of propagule size on the distances they hit the riverbed by releasing biodegradable microbeads modelled after larval and juvenile unionid mussels (range: 56 - 415 μm; density ~ 1200 kg m^{-3}). We released particles of three size classes (~150, 250, 350 μm) representing 95% of the size distribution for North American species (N = 181, mean ± SD: 240.98 ± 67.37 μm) at the Speed River, Guelph, ON. We compared empirical hitting distances from particle capture data with a laminar flow model and a turbulent flow model based on theory. Hitting distances declined with particle size in the field and were significantly different between 150 and 350 μm sizes. These differences were relatively small (~ 5 m), likely because the flow was slow and depositional (9.5 ± 0.01 cm s^{-1}). Both models underpredicted hitting distances of the 250 and 350 μm sizes. Model results for more turbulent river reaches indicate that the dispersal of smaller larvae may be increased disproportionately by increased water column turbulence, which may explain the range in observed sizes in unionids.

Catherine Febria, University of Windsor. **Local to Global: Empowering early career across the Great Lakes to engage with the UN intergovernmental platform on biodiversity and ecosystem services (IPBES).**

Engaging with the science-policy interface have never been more urgent for the Great Lakes research communities around the world. IPBES is the UN-supported intergovernmental science-policy platform on biodiversity and ecosystem services and equivalent to the globally recognized platform on climate change (IPCC). After nearly a decade since IPBES' establishment, the impact of science on global policy include the 30 by 30 Kunming-Montreal Global Biodiversity Framework and the mobilization of early-career researchers at the science-policy interface. Here I provide an overview of key assessments that have contributed to local to global impacts and key case studies of Great Lakes exemplars featured in the assessments. As a series of new assessments are on the horizon, I share a brief overview of the IPBES structure and mechanisms and showcase efforts including a recent graduate course on IPBES and sustained engagement with Indigenous and Local Knowledge holders as part of global assessments can help grow contributions by and for the benefit of Great Lakes communities. Notably, leveraging partnerships and networks across IAGLR and the newly launched UN Regional Centre of Expertise on Urban Sustainability and Education between

Wayne State University and the University of Windsor will be necessary to ensure that the next generation of researchers can obtain training to engage decision-making at local to global scales.

Jiali Feng, Maya Eve Taillon, Deema Al-Samarraie, Sesa Doshi, Claire Gullison and Patricia Corcoran, Western University. **Microplastic Pollution in Water, Sediment, Soils, and Air of Southwestern Ontario, Great Lakes Basin.**

Samples were collected from various land use areas in southwestern Ontario to determine potential sources and sinks for microplastic pollution. Most of the samples were derived from the Thames River watershed, with only minor surface sediment samples collected from the St. Clair River watershed in Sarnia, Ontario. The approximate number of samples is as follows: 80 agricultural soils from four fields, 25 bulk air samples from an agricultural setting and Chippewas of the Thames First Nation (COTTFN), 20 river water samples from agricultural and urban locations, 160 sediment samples from the Thames River and its tributaries, which flow through urban, agricultural, and rural settings, and 10 surface sediment samples from urban, recreational, rural, and industrial settings. The Thames River sediment samples were collected from the same sites in 2016, 2018, 2019, 2021, and 2022 to determine if any significant changes in microplastic abundances and morphology types have occurred over time. The results thus far indicate that in soils and sediment, fragments are the most common morphology, whereas fibers are predominant in water and air samples. Microplastic abundances are greatest in urban areas than in rural and agricultural settings. The abundances are being measured against climatic, anthropogenic, geomorphological, and sedimentological data. Once complete, the dataset will provide greater understanding of the main inputs, pathways, and sinks of microplastics in one of the largest watersheds of the Lake Erie basin.

Rodrigo Fernandez-Valdivia[1], Mala Hettiarachchi[2] and Carol Miller[2], [1]Department of Pathology, Wayne State University School of Medicine, [2]Department of Civil and Environmental Engineering, Wayne State University. **PFAS pollutants and the Great Lakes Ecosystem: Decoding PFAS exposure in breast and lung carcinogenesis.**

Per- and poly-fluoroalkyl substances (PFAS) are bio-accumulative contaminants present in water, soil, air, food, various consumer products and food packaging. Recent studies have detected PFAS in the water and fish throughout Lake Michigan and the Huron-Erie Corridor, and these environmental toxicants have also appeared in wastewater treatment plant influent and discharge effluent to water bodies and land-applied biomass. According to recent clinical and epidemiological studies as well as molecular genetics and cell-functional analyses, PFAS induce oxidative stress along with morphogenetic alterations in the lung, disrupt differentiation programs of mammary epithelial cells, and enhance the estrogen-dependent proliferation of breast cancer cells, thus indicating that these pollutants may initiate and accelerate progression of breast and lung cancers. To address this urgent environmental and health matter, the Medical and Engineering Schools at Wayne State University have initiated a strong collaborative effort to decipher the molecular circuitries and genetic programs underlying PFAS inductive role in breast and lung cancer initiation and progression. Our research indicates that perfluorooctanesulfonic acid and perfluorooctanoic acid exert a profound molecular and genetic reprogramming in the lung and mammary epithelia, and induce an increased proliferative and pro-survival response in breast and lung cancer cells. Our studies provide evidence of PFAS instructive action in breast and lung carcinogenesis and contribute to elucidating the molecular networks and cell-reprogramming processes by which these pollutants alter breast and lung function leading to neoplastic conversion.

Yasasi Fernando, Alex Neumann and George Arhonditsis, University of Toronto. **Understanding the Interactions between Cladophora, Dreissenid Mussels, and Phytoplankton: A 0-D (Box-Model) Approach.**

Cladophora glomerata is a filamentous green alga that has proliferated in the rocky nearshore zone of eastern Lake Erie and several locations in Lake Ontario since the mid-1990s, leading to extensive fouling of local beaches with decaying organic material. Cladophora blooms are influenced by several factors, including nutrient loading, light availability, and the presence of dreissenid mussels, thus requiring a more granular approach to modelling its growth and impacts. Our analysis presents the preliminary findings from a comprehensive sensitivity and uncertainty analysis focused on the interplay among bioavailable phosphorus, and three interacting modules for plankton, dreissenids, and Cladophora, within the nearshore zones of Lake Ontario. While these submodels have been studied individually, evaluation of the range of dynamics they can collectively produce has been limited. Based on our results, we revisited the existing parameterization and input specifications to accurately reflect the nearshore, small-scale processes within the Lake Ontario ecosystem. Our study clearly identifies and addresses several knowledge gaps and outstanding questions to improve our understanding of the system. We identify areas where data collection efforts are needed and ways to maximize the value of information from monitoring in the nearshore of Lake Ontario, ultimately contributing to the effective management of Cladophora proliferation in Lake Ontario.

Faith Ferrato, Josh Culpepper and Sapna Sharma, York University. **The influence of warmer fall air temperatures and delayed ice cover on under-ice water temperatures.**

Weather conditions in fall are critical to the transition from summer to winter limnological processes, as fall air temperatures dominate water cooling and ice-on timing. However, the impacts that warming fall air temperatures and delayed ice cover have on under-ice water temperatures remain unclear. Using long-term monitoring in 49 lakes across Finland, we investigate the influence of fall air temperature on lake water cooling and under-ice thermal profiles. As climate change prolongs summer stratification and delays ice formation, many lakes will experience longer fall periods before freezing. For example, preliminary results revealed that mean fall air temperatures in Lake Kevojärvi have increased by 2.6°C from 1962 to 2021, contributing to delayed ice formation by 10 days over the study period. The trend toward later formation of ice cover exposes lake water to the atmosphere for a longer period, allowing for extended heat release in the lake before freeze-up. Aquatic ecosystems support a diverse range of species and ecological processes, both of which are sensitive to temperature fluctuations and light availability. Identifying how variations in fall climatic conditions influence lake cooling improves our understanding of ice-on timing and under-ice water temperature, which are critical to biological activity under the ice.

Daniel Ferreira, Wendy Leger and Mike Shantz, Environment and Climate Change Canada. **Great Lakes - St. Lawrence River Adaptive Management Committee - Adaptive management in action.**

An ongoing adaptive management initiative in the Great Lakes - St. Lawrence River basin, spearheaded by the binational Great Lakes - St. Lawrence River Adaptive Management (GLAM) Committee of the International Joint Commission (IJC), is explored to highlight adaptive management in action. This session delves into the committee's dynamic evaluation of outflow regulation plans, specifically Plan 2014 for Lake Ontario-St. Lawrence River and Plan 2012 for Lake Superior. The adaptive management process for outflow regulation is focused on continuous monitoring of water level impacts, building relationships, refining evaluation models, and

reconsidering decisions based on emerging information and changing conditions. In response to extreme conditions in 2017 and 2019 on Lake Ontario and St. Lawrence River, the GLAM Committee is undertaking a two-phased expedited review of Plan 2014. As the committee nears the conclusion of phase two, the work highlights the significance and achievements of a structured, iterative adaptive management framework in guiding binational water quantity management decisions within the Lake Ontario-St. Lawrence River basin.

William Fetzer[1], Arthur Cooper[2], Dana Infante[2], Monir Hossain[3], Marten Koops[3], Lauren Shoemaker[4] and Jeff Tyson[5], [1]Department of Zoology and Physiology, University of Wyoming, [2]Department of Fisheries and Wildlife, Michigan State University, [3]Fisheries and Oceans Canada, Burlington, Ont, [4]Department of Botany, University of Wyoming, [5]Fishery Management Coordination, Great Lakes Fishery Commission. **Linking environmental drivers and fish community dynamics across the Great Lakes.**

Environmental gradients and ecosystem change can influence fish community composition, species interactions, and relationships between ecosystem productivity and fish biomass, all of which modify fisheries productivity and stability across space and time. Existing efforts to characterize factors driving fish community dynamics in the Great Lakes have generally focused on local and regional change; however, there is a need to conduct assessments of fisheries dynamics across temporal and spatial scales. Over the past decade, the Great Lakes Aquatic Habitat Framework (GLAHF) has facilitated management, research, and policy making by providing a consistent geographic framework to link, integrate, map, and track physical, chemical, and biological changes across the Great Lakes. However, data from long-term fish community surveys are fairly limited in GLAHF, making it difficult to identify cross-scale drivers of fish community dynamics in the Great Lakes. Recently, the GLFC-funded Phosphorus-to-Fish (P2F) project collated nearly 40 fish community surveys across the Great Lakes and calculated long-term trends in fish biomass. Our research is working to update key environmental layers and integrate the P2F database into GLAHF to identify cross-scale relationships between environmental conditions and fish community dynamics across the Great Lakes. Results will contribute to on-going GLAHF efforts to classify and assess habitats, conduct ecological forecasting, estimate habitat and fisheries effects of potential rehabilitation projects, and monitor and track rehabilitation activities across the Great Lakes.

Deanna Fielder[1], Frank Seglenieks[2, 3], Lauren Fry[3, 4] and James Kessler[4], [1]U.S. Army Corps of Engineers, Detroit District, [2]ECCC National Hydrological Service, [3]Great Lakes - St. Lawrence River Adaptive Management Committee, [4]NOAA Great Lakes Environmental Research Laboratory. **Long-Term Trends in Great Lakes Water Levels and Precipitation.**

Water levels and precipitation are two critical datasets that aid in understanding hydroclimate changes and impacts in the Great Lakes basin. Historical analyses of these variables are incorporated into the State of the Great Lakes Report to help identify challenges and potential risks to the Great Lakes, but these assessments can also be applied towards adaptive management in the Great Lakes region. Both datasets provide relatively long periods of record, which allow for an analysis of trends over extended time-periods. Also, an important aspect in Great Lakes hydroclimate is seasonality. High amounts of precipitation or lack of precipitation can have a large impact on the seasonal cycle of water levels, including the timing and magnitude of the seasonal rise and decline on each lake. This presentation will build off the State of the Great Lakes Report from 2022 and examine trends, seasonality, and other features of the water levels and precipitation datasets that help to represent potential changes in the Great Lakes hydroclimate over their respective periods of record.

Christopher Filstrup[1], Alexander Frie[2], Sarah Janssen[3], Michael Tate[3], Zachary Wagner[1] and Euan Reavie[1], [1]Natural Resources Research Institute, University of Minnesota Duluth, [2]Minnesota Sea Grant College Program, University of Minnesota Duluth, [3]Upper Midwest Water Science Center, U.S. Geological Survey. **Metals Distribution in Lake Superior and Huron sediment track changing watershed and airshed sources.**

Heavy metals can accumulate in the environment, where they present public health risks and can degrade habitat quality. Spatial distributions of heavy metals in sediments within the Laurentian Great Lakes integrate a myriad interacting processes (e.g., hydrogeology, lake circulation patterns, contaminant sorption properties), whereas temporal trends also reflect changes in industrial uses. Critical knowledge gaps in the fate and transport of heavy metals and limited comprehensive, lake-wide assessments of heavy metals sediment concentrations make it difficult to trace sources. As part of the EPA Great Lakes Sediment Surveillance Program, we analyzed metals in surface sediments and sediment cores collected throughout Lake Superior and Lake Huron to improve knowledge of fate and burial processes, identify potential sources within the watershed and airshed, and evaluate temporal changes. Preliminary findings from Lake Superior indicate that surface sediment concentrations (representing < 5 y) were (1) positively related to organic matter content and negatively to sediment grain size, and (2) generally higher in deeper, offshore stations except for higher concentrations near tributary sources. Positive Matrix Factorization (PMF) analyses revealed that offshore stations had strong atmospheric deposition contributions, whereas tributary stations had greater terrestrial contributions, with metal compositions reflecting local geology. Lake Superior sediment cores revealed that (1) lead and mercury concentrations peaked in the 1960s/70s, a signature of fossil fuel combustion; and (2) cadmium and copper concentrations have been relatively constant since the 1960s.

Dean Fitzgerald[1], Jessica Zadori[2], Fraser Gibson[3] and Edward Kott[4], [1]Integrated Ecosystem Solutions Inc., [2]Michipicoten First Nation, [3]Waterloo Region Nature, [4]Biology Department, Wilfrid Laurier University. **Evaluation of Flood Plain Surveys to Inventory Freshwater Mussels in place of River Surveys.**

Episodic events can represent a unique opportunity for learning about processes evident in ecosystems. Flooding of rivers represents an episodic event with opportunities to learn about how turbulent flows influence physical and biological features within floodplains. A key consideration with quantifying influences of flooding is the analysis may represent an un-replicated study. However, if flood responses are studied over multiple seasons, repeated inventories of physical and biological features can be quantified and identify patterns within these habitats. Inspections along the un-impounded Nith River, part of Grand River in Ontario, were completed from 2018 to 2022, within an area of approximately 600 m^2. When this area was inspected, it involved citizen scientists from Waterloo Region Nature and others, and the shells were used to identify freshwater mussel species. When comparing the identity of 2000+ mussel shells deposited in this flood plain, it was found that the biodiversity of freshwater mussel species on land is likely comparable to that within the Nith River itself, based on historical in-water records. Other analyses in the flood plain identified an inverse relationship exists between length of the mussel shell and displacement from the edge of the river during spring floods. These results suggest that surveys of flood plains represents a viable initial assessment tool for freshwater mussels prior to surveys within rivers. These results also demonstrate how citizen-based community involvement can enhance environmental management.

Faith Fitzpatrick[1], Peter McCarthy[1], Susan Wherry[1], Joshua Valder[1] and John Nelson[2], [1]U.S. Geological Survey, [2]Department of the Interior. **New Tools for Planning and Tracking Oil Spills in Great Lakes Rivers.**

Over the last decade, the interest in oil spill tracking tools and models for rivers has greatly increased for both planning and response applications across the U.S. and Canada. As part of the Department of Interior's Inland Oil Spill Preparedness Program, the U.S. Geological Survey has been able to adapt existing plume models and tracking tools to the inland riverine oil spill environment. Of special interest are rapid tools that use publicly available hydrologic and topographic data, and ultimately link to realtime river flows and currents. After the 2010 spill of diluted bitumen into the Kalamazoo River, the number of modeling tools that included oil-river sediment interactions increased to help identify potential river depositional zones of oil-particle aggregates that might pose an ecological risk for benthic communities and prolong clean ups. With the number of tools and models growing, the spill planning and response communities need readily available information on what tools are available and the resources needed to use them. For the Great Lakes region, an additional need is linking river models and tools through lake-affected backwater zones and estuarine wetlands to lake nearshore, open water, and shoreline models. The presentation will give a brief overview of example river tracking tools, focusing on those that can be used for planning or rapid response (first few days of a spill).

Kristina Flanigan, Robert Hunter, Ryan Brown, Song Qian and Christine Mayer, University of Toledo. **Two analytical methods for calculating sampling effort of an invasive fish.**

Grass Carp (*Ctenopharyngodon idella*) are the only one of four invasive carp known to reproduce successfully in the Great Lakes, and their presence threatens ecosystem services provided by wetlands. To reduce the threat of population growth and expansion, Grass Carp removal using electrofishing and electrofishing combined with trammel nets was the first step in a multijurisdictional adaptive response. Assessing management action efficacy requires monitoring changes in population demographic parameters that may depend on quantitative methods used to standardize effort. Initial attempts to standardize effort across the lower 24 km of the Sandusky River, OH, USA, used fixed net lengths to calculate a linear shoreline distance. However, the assumption that all efforts occur within a fixed net area is often violated. Therefore, we present a model that calculates thalweg distance and a shoreline model that calculates right and left shoreline distance and estimates sampling area. On average, the mean distance estimated from the shoreline model was ~10% greater than the thalweg model (paired t-test: $t = 11.22$, $df = 281$, $p = <0.001$). Given the strong correlation between the two model estimates, the simple thalweg model is better to estimate population demographic parameters because it has fewer assumptions. However, the shoreline model produces area estimates on each river shoreline which can be combined spatially with habitat measurements to generate hotspot maps to guide future removal.

Amanpreet Kohli[1,2], **Carolyn Foley**[1,2] and Sarah Zack[1,3], [1]Illinois-Indiana Sea Grant, [2]Purdue University, [3]University of Illinois at Urbana-Champaign. **"We Don't Know What We Don't Know": Supporting Research on Social and Economic Impacts of PFAS.**

Per- and polyfluoroalkyl substances (PFAS) are toxic, manufactured chemicals of emerging concern (CECs). These chemicals and their precursors comprise a suite of 10,000+ CECs, where key exposure pathways include ingestion through food and water, inhalation through air and dust, and dermal exposure with consumer products. As with other chemicals, certain communities are at higher risk of experiencing negative effects than others. Some of these, e.g., firefighters, are relatively well-aware of the potential risks, with policies being enacted to mitigate their exposure, while others

have little or no awareness of the risks or how to mitigate them. It is unclear how to best share information in a way that encourages Great Lakes communities and individuals to take protective actions, in part because there remains so much to be learned about the mechanics of PFAS toxicity, exposure routes, and which PFAS are most problematic in a given area or for a given population. However, we argue that despite the unknowns, it is important to communicate what is known with those experiencing exposure, emphasizing that more information is forthcoming. In this presentation, we will summarize work led by Illinois-Indiana Sea Grant to support communities that are exposed to PFAS and related compounds. We will summarize information gathered via three scoping sessions and a competitive research opportunity, highlighting regional research questions that were identified, including some that are currently being investigated.

Sam Francis, Jay Martin, Michael Brooker, Nathan Stoltzfus and Brian Roe, The Ohio State University. **The Right Practice to the Right Place: A Cost-Benefit Analysis of Targeting Agricultural Phosphorus.**

Agricultural sources of legacy (long-term) phosphorus present a unique challenge to nutrient management in freshwater systems (e.g. Lake Erie): even when phosphorus application ceases, these fields can continue to leach phosphorus for decades, driving harmful algal blooms. Common conservation programs (e.g., the Farm Bill) require producers to seek out and enroll in these programs, creating a barrier to access that might prevent fields leaching the most phosphorus from being enrolled. We theorized that, compared to existing conservation programs, a program that targets conservation practices to these legacy phosphorus sources would capture a greater load of phosphorus per area of land treated, but would the same per load of phosphorus removed. To test this, our research team partnered with crop advisors, producers, the USDA, and The Nature Conservancy, to create a public-private partnership (PPP). In this presentation, we evaluate the PPP by comparing its costs and benefits to traditional conservation programs. Specifically, we describe the phosphorus removed, resources used, and costs associated with each program. The results are used to evaluate tradeoffs that occur based on the proportion of a budget invested in a targeting program versus a common conservation program at the watershed-scale. Understanding these tradeoffs are necessary to plan nutrient management at the watershed-scale, mitigating the legacy phosphorus loss that impairs Lake Erie water quality.

Benjamin Frey and Jennifer Wong, U.S. Fish and Wildlife Service. **Saginaw Bay to Western Lake Erie Coastal Wetland Conservation Blueprint.**

This project focuses on the restoration and conservation of coastal wetlands in the Great Lakes region, spanning from Saginaw Bay, Michigan, to Western Lake Erie, Ohio. The importance of these wetlands lies in their multifaceted ecological functions, such as nutrient capture, carbon sequestration, erosion protection, and support for diverse species and communities. Over time, urbanization or agricultural purposes drained many wetlands in these areas, compromising their natural habitat. The Great Lakes Restoration Initiative has collected extensive data on these wetlands and developed decision support tools for coastal wetland managers. Phase I of this Conservation Blueprint, initiated in 2016, aimed to identify conservation targets and developed coastal wetland indicators to track changes in wetland conditions. In 2022, Phase II was launched, focusing on refining indicators, creating maps & mapping tools, and developing an Implementation Plan. Phase III, which began in January 2024, aims to ensure that the final products align with diverse stakeholder interests, fostering broad investment in shared priorities and strategic collaboration. The specific goals for Phase III include completing a comprehensive Implementation Plan, developing a web-based platform with final maps and interactive tools, and establishing a strategy for the long-

term sustainability of the Blueprint partnership. This final phase, completing in September 2024, seeks to enhance coastal wetland conservation efforts and promote effective, collaborative conservation practices across the Saginaw Bay to Western Lake Erie basin.

Karl Friesen-Hughes[1], Alexis Kanu[1], Chelsea Lobson[1], Greg McCullough[1, 2] and Nora Casson[1, 3], [1]Lake Winnipeg Foundation, [2]University of Manitoba, [3]The University of Winnipeg. **Phosphorus hotspots in the Lake Winnipeg watershed: finer resolution export data to inform targeted action.**

Lake Winnipeg has a massive watershed with a complex network of rivers and streams, as well as smaller tributaries. Lake Winnipeg has increasingly struggled with harmful algal blooms, the primary cause of which is understood to be phosphorus loading. The Lake Winnipeg Community-Based Monitoring Network (LWCBMN), coordinated by Lake Winnipeg Foundation, is a growing network of watershed district partners and citizen scientists who collect water samples from across Manitoba in order to measure phosphorus concentration. Most LWCBMN sampling occurs at sites where water flow is continuously monitoring by the Water Survey of Canada. Frequent and responsive sampling at these stations enables the calculation of phosphorus load and export, which allows LWCBMN to fill a critical knowledge gap in understanding phosphorus hotspots at finer resolution throughout the Lake Winnipeg watershed. Action dedicated to improving the water quality of large lakes should be targeted in places it will have the biggest impact. Thus, identifying hotspots of phosphorus loading is a requirement to efficient, responsive action. LWCBMN findings have important policy implications for the effective management of phosphorus loading to prevent algal blooms in Lake Winnipeg. They are particularly relevant to the implementation of the Canadian federal government's renewed Freshwater Action Plan.

Lauren Fry, NOAA Great Lakes Environmental Research Laboratory. **GLERL Hydrology collaborations to advance monitoring, understanding and prediction of water level variability.**

Since the establishment of the NOAA Great Lakes Environmental Research Laboratory, the lab has played a large role in the advancement of hydrological modeling to support water management and resiliency. Decades of research has resulted in new process understanding related to changes in water supply components and the linkages among water supply, water levels, connecting channel flows, and outflow regulation. Much of this work has been conducted in collaboration with federal agencies on both sides of the border, as well as with the academic research community. This presentation will describe the advancements made by GLERL hydrologists and their collaborators over the past five decades. The presentation will highlight the data products, observational networks, forecasts, and collective understanding of drivers of water level variability that have evolved since the establishment of GLERL.

Lauren Fry[1], Dani Jones[2], Yi Hong[2], Riley Ravary[2], Andrew Gronewold[3], Amy Van Zanen[3] and Jamie Ward[2], [1]NOAA Great Lakes Environmental Research Laboratory, [2]University of Michigan Cooperative Institute for Great Lakes Research, [3]University of Michigan School for Environment and Sustainability. **Subseasonal-to-Annual Net Basin Supply and Water Level Forecasting for Great Lakes Water Management.**

Variability of water levels on seasonal to annual time frames has clear implications for water resources management (e.g. outflow regulation) and coastal resiliency planning (e.g. addressing compound flooding challenges). However, current operational forecasts do not extend beyond 6 months and are limited in their ability to predict extremes and shifts in water level regimes that are

important over longer time horizons. Work is underway to develop a next generation subseasonal to annual Great Lakes water supply and water level forecast framework that incorporates advanced understanding of regional and global sources of predictability of regional hydroclimate through a data- driven modeling approach. We are applying a co-development approach that incorporates input from operational partners and end users through stakeholder engagement and social science. We will present (1) initial findings from research investigating sources of predictability, and (2) an overview of the conceptual forecast design that integrates these findings and stakeholder engagement results into a framework for water supply and water prediction aimed at meeting the challenges faced by water managers, resiliency planners, and coastal communities.

Nikki Fuller, Evan Batte, Paige Arieno, Jayson Kucharek, Steven Day, Matthew Hoffman and Christy Tyler, Gosnell School of Life Sciences, Rochester Institute of Technology. **The impact of environmental filters on debris transport across a rural to urban gradient in the Lake Ontario watershed.**

Mismanaged waste poses significant environmental threats that contribute to pollution and ecosystem degradation in the Great Lakes region. Estimates of debris input to the Lakes often assume that land-derived material is transported rapidly downstream. However, environmental filters, such as stormwater retention ponds, riparian zones, and green infrastructure, can act as temporary or permanent repositories, reducing debris loading to the Lakes and creating hotspots of accumulation across the landscape. Much is still unknown regarding the movement, entrapment, and fate of land-based plastic and debris between entry and ending point. We quantified, categorized (material and use), and identified (using FT-IR for plastics only) micro (<5 mm) and macro (>5 mm) debris entrapment seasonally in these environmental filters across a rural to urban gradient in the watershed of the Rochester Embayment of Lake Ontario. Plastic was the most common macro-debris material across all locations. Land use, location, and seasonality impacted debris abundance, with urban areas greater than suburban and warm seasons more than cool. Carbonyl indices, used to assess degradation of plastic, showed a range of degradation, suggesting some sites and land use may be more permanent repositories for debris. Ultimately, these results will aid in estimating the role of environmental filters in preventing downstream transport of debris, closing the gap on debris sources and sinks in the Great Lakes Basin, and informing targeted mitigation measures.

Tyler Funnell[1, 2], Christopher Holbrook[1] and Travis Brenden[2], [1]United States Geological Survey, [2]Michigan State University. **Lakewide movements of lake whitefish (*Coregonus clupeaformis*) from US waters of Lake Huron.**

Lake whitefish (*Coregonus clupeaformis*) is a culturally, ecologically, and economically important coldwater fish native to the Laurentian Great Lakes. Population abundances and commercial yields of lake whitefish have declined in several of the Great Lakes, including Lake Huron, since the late 1990s. Declines have been associated with declining recruitment levels ostensibly linked to ecosystem changes, including dreissenid mussel establishment and expansion, population collapse of *Diporeia* sp., and climate change. However, the relative contribution of each of these factors to lake whitefish declines are unknown. Population modeling has been used to quantify the extent of recruitment declines and factors contributing to the decline; however, substantial intermixing among spawning populations and the potential for source-sink dynamics complicates these modeling efforts. We used acoustic telemetry to collect fishery-independent movement data of lake whitefish at a lakewide scale in Lake Huron to better understand the potential for source-sink dynamics. Preliminary observations from 80 lake whitefish tagged as a pilot effort indicated that 71% of fish occupied more than one management unit and 29% of fish tagged in US waters spent time in

Canadian waters. Efforts are underway to increase the sample size of this study, the final results of which will inform habitat use, mixing of spawning populations during non-spawning seasons, and potential source-sink dynamics of subpopulations. These results will help to inform management for sustainability of the fishery in a changing ecosystem.

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Marc Gaden, Great Lakes Fishery Commission. **Cross-border science, sea lamprey control, and management of the shared Great Lakes fishery.**

Two nations, eight states, the Province of Ontario, and scores of Indigenous nations share in the management and protection of Great Lakes' natural resources. Cross-border cooperation, particularly with the fishery, has not always been the case. Government entities, at all orders and from both nations, coordinate fishery management decisions, establish and implement a cohesive science agenda to aid fishery management, and address some of the region's most pressing challenges like habitat loss, invasive species, and nutrients. This presentation will describe the history of cooperation (or lack thereof) over the Great Lakes fishery, leading to the successful ratification of the 1954 Convention on Great Lakes Fisheries, an agreement between the United States and Canada that created the Great Lakes Fishery Commission. The presentation also will discuss strategies the commission employs to facilitate cohesive, multi-jurisdictional management of the shared Great Lakes fishery (particularly at the sub-national level); to develop, implement, communicate, and fund a theme-driven, basinwide research agenda that supports fishery managers; and to address the sea lamprey, a destructive, invasive pest that requires a bi-national control effort. This presentation will argue that well-conceived structures, many of which were established decades ago, ensure a high degree of cross-border cooperation over the shared Great Lakes fishery.

Angus Galloway[1], Peter C Esselman[2], Anthony Geglio[2], Shadi Moradi[3], Jennifer M Morris[2], Joseph Geisz[3] and Graham W Taylor[4, 5, 6], [1]Engineering Technologies Canada Ltd., [2]U.S. Geological Survey Great Lakes Science Center, [3]Michigan Technological University, Contractor to the U.S. Geological Survey, [4]University of Guelph, [5]Vector Institute for Artificial Intelligence, [6]CIFAR. **MusselFinder: Automatic Dreissenid mussel analysis from AUV imagery in Lake Michigan.**

Quagga mussels (*Dreissena rostriformis bugensis*) and the closely related zebra mussel (*Dreissena polymorpha*) are prolific invasive species in the Laurentian Great Lakes, often visible in lakebed photos. Presently, *Dreissena* spp. are monitored using labor intensive methods such as Ponar grab sampling and manual enumeration. Current methods have limited utility for high resolution lake-wide monitoring, and do not work on all substrates. In this work, we leverage lakebed images collected with an autonomous underwater vehicle (AUV). The AUV yielded a large dataset from which mussel abundance was determined manually and automatically using a deep neural network (DNN). The annotated dataset contains N=84,672 image patches with segmentation labels obtained by tracing pixels with mussels present, and N=10,232 higher-resolution images in which more than one million mussels were dot-annotated by placing one dot on each mussel. DNN prediction performance was assessed relative to the number of dot-annotated mussels per image. DNN performance was judged against AUV missions spanning diverse substrate and algae conditions. The DNN obtained R^2 scores of 0.87 (N=3996), 0.93 (N=4118), and 0.82 (N=1441) for held-out test sets respectively characterized by i) high-altitude over sand, ii) low-altitude over cobble, and iii) low-altitude over cobble and algae. We suggest that methods combining AUVs and DNNs have the

potential to expand the scale and statistical robustness of *Dreissena* monitoring and assessment, while also accelerating the delivery of results.

Olivia Galloway[1], Christine Madliger[2], Justin Chiotti[3] and Trevor Pitcher[1], [1]University of Windsor, [2]Algoma University, [3]USFWS. **Physical enrichment as a tool for minimizing the environmental mismatch in hatchery-reared Lake sturgeon.**

Reintroduction programs are a new tool to facilitate the recovery of imperilled fishes and address drastic declines in freshwater biodiversity. However, a large percentage of reintroductions have failed. One explanation for reintroduction failure is that benign captive environments impose artificial selection pressures that can lead to maladaptive morphological, behavioural, and physiological phenotypes not observed in wild conspecifics. Captive rearing can lead to an "*environmental mismatch"*, whereby captive-reared individuals are phenotypically mismatched to the natural environment upon release. One way to minimize the environmental mismatch in captive-reared fish is to use physical enrichment (e.g. structures, artificial plants, and substrates) to increase structural complexity of the rearing environment. Physical enrichment can reduce the negative effects of benign environments and improve growth performance, increase survival, and reduce stress. We exposed juvenile Lake sturgeon to different levels of physical enrichment, namely gravel substrate and vertical plastic structures, for six months. We test the hypotheses that physical enrichment will significantly affect 1) body condition and growth rate over time; 2) the stress response and 3) individual thermal tolerance of juvenile Lake sturgeon. These data will help inform reintroduction programs in place for Lake sturgeon in the Great Lakes by minimizing the environmental mismatch for juveniles prior to release.

Yunpeng Gao[1], Evan A. Angus[1], James W. Roy[1, 2], Jinfei Wang[3] and Clare E. Robinson[1], [1]Department of Civil and Environmental Engineering, Western University, [2]Water Science and Technology Directorate, Environment and Climate Change Canada, [3]Department of Geography and Environment, Western University. **Application of geospatial tool to estimate septic system wastewater effluent contributions to tributaries in the Canadian Lake Erie and Lake Simcoe Basin.**

Quantifying the amount of septic system wastewater effluent that reaches surface waters is needed to inform water quality management programs as septic effluent contains a wide range of pollutants including nutrients, pathogens and contaminants of emerging concern. However, this quantification is challenging because there is no existing inventory of the numbers and locations of septic systems across Ontario and there is high uncertainty regarding how much septic effluent actually reaches tributaries. The study objectives are to i) develop a geospatial tool to improve identification of individual septic systems locations across the Lake Erie and Lake Simcoe Basins, and (ii) apply the placement results together with statistical analysis of field data to provide estimations on septic wastewater effluent loads to tributaries. The geospatial placement tool was developed using a remote sensing and machine learning approach to locate septic systems near houses not serviced by WWTPs. Estimation of septic effluent inputs to tributaries was based on analyzing sampling data from 53 subwatersheds to assess whether the fraction of septic effluent reaching streams varies based on physical and socio-economic watershed characteristics (e.g., surficial geology, household age). Statistical analyses showed that the amount of septic effluent reaching tributaries is higher in more rural watersheds with older households and a high density of agricultural tile drains. Study findings are needed to improve pollutant load estimates to streams and to inform septic system best management practices.

Jorge Garcia-Hernandez, Serghei Bocaniov, Roy Brouwer, Narasimman Lakshminarasimman and Philippe Van Cappellen, University of Waterloo. **Optimization of Nutrient Reduction Measures Targeting Agricultural and Urban Sources around Lake Erie.**

Nutrient export from agriculture and urban sources has been identified as a major threat to the water quality of the Laurentian Great Lakes. Phosphorus (P) loads have contributed to undesirable levels of eutrophication on Lake Erie (LE). In response to these quality changes, Canada and the US have adopted total P (TP) target reductions for LE. In this work, we present an optimization model for the Canadian LE watersheds that determines the required abatement level of TP in agricultural activities and investments in end-of-pipe technologies in wastewater treatment plants, such that a target reduction in P concentration is achieved at the lowest cost. The hydrological model used in this study considers the interdependence among six regions: St. Clair River, Lake St. Clair, Detroit River, and the Western, Central, and Eastern Basins of LE. Preliminary results show that a drop of 1 ppb in P concentration for the Western and Central Basins would cost 370 million CAD and involves reducing TP loads by 150 tonnes in the St. Clair River and Lake, 185 tonnes in the Detroit River and the Western Basin, and 303 tonnes in the Central Basin. The model also shows a positive externality for the Eastern Basin as it would decrease its P concentration by 0.5 ppb. This newly developed model will be very informative for policymakers on the most cost-effective way to abate TP emissions into LE.

Stephen Gasteyer, Michigan State University. **Local Social Systems and Phosphorous Reduction: Insights from the Western Lake Erie Basin.**

The achievement of phosphorous nutrient reduction goals through the implementation of domestic action plans (DAPs) must involve better understanding farmers and agricultural land management as part of social systems that have multiple actors and complex structures that incentivize the implementation of best management practices. This paper will use a meta-analysis of previously implemented field research to offer insights about the complexity of the system and opportunities for work with actors in the system to achieve nutrient reduction goals. In particular, the paper will discuss the role of farmer-led groups in conservation activities, conservation challenges and opportunities for young and women farmers, the opportunities and barriers of engaging crop advisors and farm credit organizations in conservation activities, and strategies for more direct engagement with farmers around nutrient management. The paper will conclude with a discussion of challenges and opportunities presented by the changing structure of agriculture and efforts to adapt agricultural production to changing economic and climatic conditions. The paper will highlight that while there are significant challenges ahead for achieving nutrient reduction targets, there are opportunities for engagement that could yield improvements in conservation practices going forward.

Noah Gauthier, University of Ottawa. **Caring for Sea Lamprey: Risk Management, Biotechnology, and Eradication in the Great Lakes.**

The escalating sociocultural, political, and economic challenges linked to current suppression measures for invasive sea lamprey control are reaching an unsustainable threshold. Amid rising concerns regarding the persistent costs and ecological impacts of using lampricides and barriers, the GLFC is advocating genetic control as a cost-effective solution, potentially implementable as early as 2040. Funded by SSHRC, this research critically examines the feasibility of employing CRISPR/Cas9 technology for sea lamprey control in the Great Lakes within an acceptable social and political context. While genetic control offers potential cost savings and the prospect of eradicating sea lamprey, the research specifically addresses the inter-jurisdictional challenges inherent in

transboundary science and underscores the paramount importance of Indigenous sovereignty and inclusion. Anticipating potential turbulent waters when approving genetic control, the research also underscores an early opportunity to cultivate new relationships and undertake reconciliatory actions among rightsholders.

Anthony Geglio[1], Shadi Moradi[2], Joseph Geisz[2] and Peter Esselman[1], [1]US Geological Survey Great Lakes Science Center, [2]Michigan Technological University. **GobyNet: Catching Round Goby with neural nets instead of trawl nets.**

Research on aquatic species detection in images of unconstrained underwater environments remains challenging due to image quality, water turbidity, fish avoidance, and variable illumination. Despite these challenges, we demonstrate the efficacy of state-of-the-art deep-learning algorithms for detecting round goby—an important prey species for Great Lakes predators—in lakes Michigan, Huron, and Ontario. Underwater imagery was collected in a series of surveys using autonomous underwater vehicles from 2019 to 2023 as part of an ongoing effort to monitor status and trends of Round Goby. We compared the performance of the "single-stage" object detector RetinaNet, and the latest YOLO models which have been shown to outperform their contemporaries with rapid inference time. YOLO version 8 outperformed RetinaNet when evaluated against high quality external test data, achieving an F1 score of 81% compared to 65% for RetinaNet. We also demonstrate how the bounding boxes defined by YOLO version 8 can be used to estimate individual fish lengths with reasonable precision ($R^2 = 0.88$). In addition to having high catch efficiency compared to conventional trawl methods, deep learning based approaches offer other advantages including high spatial accuracy, the ability to "recapture" fish as algorithms improve, and the ability to quantify ecological covariates (substrate, prey abundance, etc.) from the same imagery. We suggest that the solution is ready for full-scale, automated deployment in annual surveys of round goby moving forward.

Bikie Gerald Anicet[1], Mbong Aicha Kang Saidou[2], Eloundou Abega Jean Jovanick[2], Alexander Samuel Kolker[3] and Achab Mohammed[1], [1]scientific Institute of Rabat, [2]National Advanced School of Public Works Cameroon, [3]The Louisiana Universities Marine Consortium. **Modeling and Spatiotemporal Monitoring of Marine and Coastal Ecosystems of the Moroccan Margin of the Gulf of Cadiz and the Gulf of Guinea: A Hybrid Approach for Spaceborn Oceanography and Artificial Intelligence.**

Studying ecosystemic parameters and accurately extracting the latter plays a crucial role in assessing the health and dynamics of coastal and marine environments. Satellite imagery provides a valuable source of data for studying these parameters. However, effectively utilizing satellite imagery requires an in-depth analysis of data sources, softwares, and IT tools specifically designed for the visualization, processing, modeling, and extraction of coastal and marine parameters. This research work aims at exploring the range of data sources available for obtaining satellite images, including sensors such as SeaWiFS, MODIS, VIIRS, and others via a systemic analysis of existing solutions and to initiate the creation of an AI based geospatial webapp. The geospatial AI based webapp prototype under development for researchers and scientists in this research piece is called ANICK. Additionally, we delved into software and IT tools to assess the potentialities of existing approaches of both image processing and data analytics which led to the selection of the transfer learning AI technic as the main result optimizer. The end goal is to ensure automation, efficiency and result optimization for the spatiotemporal modeling and assessment of coastal and marine ecosystems in both the Gulf of Guinea and the Moroccan margin of the Gulf of Cadiz.

Kevin Obiero[1], Mulugeta Wakjira[2], Natasha Gownaris[3], John Malala[1], James Last Keyombe[1], Migeni Ajode[4], Stephanie Smith[4], Theodore Lawrence[4], Erick Ogello[5], **Abebe Getahun**[6] and Jeppe Kolding[7], [1]Kenya Marine Fisheries Research Institute, [2]Jimma University, [3]Gettysburg College, [4]African Center for Aquatic Research and Education, Ann Arbor, [5]Maseno University, [6]Addis Ababa University, [7] University of Bergen. **Lake Turkana: Status of world's largest permanent desert and alkaline lake.**

Lake Turkana, shared between Kenya and Ethiopia, is the northernmost of the African Great Lakes. It is the world's largest permanent desert lake and the largest alkaline water body. Turkana has been called the "cradle of mankind" due to the preponderance of early hominid fossils. The lake's area is 7,560 km^2, with maximum and mean depths of 114 and 31.4 m, respectively. More than 90 % of the inflow is from the Omo River. Lake Turkana is considered the least studied of the African lakes. However, new initiatives have recently emerged including formation of Lake Turkana Advisory Group facilitated by ACARE, which works on strengthening science, research, and education on the African Great Lakes for lake management and livelihood improvement. Wageningen University, in collaboration with KMFRI, has also initiated a baseline study of Lake Turkana. The lake is species rich, supporting 79 fish species; over 350 bird species; 13 mammal species; 4 species of endemic reptiles; and 3 species of frogs. The fishery is critical to the surrounding local communities; however, the resources are understudied and underutilized due to lack of material and technical support and government commitment. Lake Turkana is facing several threats including climate change; insufficient knowledge and skills; biodiversity decline; conflicts in fishery resources and land use/habitat destruction. In this presentation, we discuss these threats, future needs and actions to protect and sustainably utilize this valuable lake.

Alireza Ghane, Ecometrix Incorporated. **The Interaction Between Thermocline and Chemocline in a Pit Lake.**

Pit lakes, formed within excavations of open-pit mines, exhibit unique characteristics due to diverse geochemical inflows and steep basins, rendering them more prone to meromixis than natural lakes. This research employs a comprehensive, interdisciplinary approach, incorporating water column sampling and a three-dimensional modeling. Our objective is to explain the complex interplay between the thermocline and chemocline. We seek to understand their role in initiating phytoplankton. Primary areas of focus encompass investigating the impact of meteorological factors on thermocline variability. Furthermore, we aim to analyze how this variability influences the chemocline and subsequently affects the upwelling and cycling of materials from below the chemocline to the upper layer. The insights derived from this study are vital for comprehending the mechanisms governing stratification and biogeochemical processes in pit lakes. Such knowledge provides invaluable information for the development of sustainable lake management and remediation strategies in similar lakes.

Uttam Ghimire and Prasad Daggupati, University of Guelph. **Investigating the impacts of agricultural best management practices on nitrous oxide emissions.**

Despite many studies investigating the impacts of agricultural best management practices (BMPs) on sediments and nutrients in Southern Ontario, Canada, very few have studied their impacts on nitrous oxide (N2O) emissions. As agricultural remains primary emitter of N2O, the impacts of reduced nutrient application, reduced tillage, no tillage, conservation cover and cover crops on crop yield, instream sediment and nutrients and annual N2O emissions were studied in the Speed River Basin (SRB) using a modified Soil and Water Assessment Tool (SWAT). All BMPs reduced instream sediments and nutrients in varying ranges in the SRB. While reduced and no tillage

practices improved the sediment and nutrient retention in watershed, they increased the N2O emissions. A complete conversion of agricultural lands to a conservation cover was found to yield the highest benefits in sediment, nutrients and N2O emissions, but by losing the entire crop yields, it remains undesirable from the agricultural perspective. The best results yielded from cover crops when introduced between corn and soyabean and mineral fertilizers were banded rather than surface broadcasted. A reduction of ~9% annual N2O emissions, ~12% sediments, ~21% phosphorus and ~8% nitrogen was observed with the combination of cover crops and banded fertilizer application. It is expected that these results will guide agricultural practitioners to adopt relevant best practices in southern Ontario to yield optimal environmental benefits while maintaining the existing crop yields.

Adam Gillespie, Stephen Sumary, Liam O'Hara, Serra-Willow Buchanan, Jordan Grigg, Nick Letwin, James Longstaffe and Ryan Prosser, University of Guelph. **Microplastic characterization in municipal composts, biosolids, and amended agricultural soils.**

Microplastics (MPs) have been detected in terrestrial and aquatic environments, which has raised public health concerns during the past decade. In Southern Ontario, Lake Ontario and Lake Simcoe are the major water bodies which may receive the highest estimated loads of microplastics from overland runoff. One major contributor is the potential disproportionate loading that these lakes may undergo because of land application of urban-derived compost and biosolids as organic soil amendments. Agricultural soils have been identified as susceptible to MP accumulation from biosolids and compost, which are used as fertility and organic matter amendments. In addition to movement of MP to water bodies from soils, there remains a gap in the understanding of how MPs change chemically from the processes of composting and biosolids production. Despite MP persistence and stability in the environment, chemical changes to their surfaces may change their reactivity. Here we present results from a study of the types, numbers, and potential degradation products from microplastics extracted from municipally derived biosolids and compost products and from soils receiving these amendments. These results show that MP in composts varies widely and does reflect varied green bin rules across municipalities, whereas biosolids are much more uniform. MP also have been detected in soils receiving these materials and show clear evidence of altered chemistry from environmental exposure.

Hillary Glandon[1], Austin Happel[2], Jacques Rinchard[3] and Sergiusz Czesny[1], [1]Illinois Natural History Survey, [2]Shedd Aquarium, [3]SUNY Brockport. **The effects of tissue, lipid content, and time on predator-prey fatty acid profile resemblance.**

There is interest in quantifying feeding preferences of lake trout (*Salvelinus namaycush*), a native top predator in the Great Lakes, to determine the influence of diet on lake trout growth and reproductive success. Fatty acid profiles can be used to illustrate trophic interactions and quantify long-term diet preferences, but the resemblance of predator fatty acid signatures (FAS) to that of their prey is dependent on a variety of external factors. In this study, juvenile lake trout were fed either round goby (*Neogobius melanostomus*) or alewife (*Alosa pseudoharengus*) over a period of 12 months to illustrate how tissue type, lipid content, and time influence the similarity of the FAS of lake trout tissues to that of their diet. A subset of round goby-fed lake trout from Year 1 were fed either alewife or round goby for an additional year to determine if a diet switch could be reflected in the FAS of lake trout. We observed that the resemblance of lake trout FAS to that of their prey was dependent on prey type, tissue type, and varied over time. Our data from Year 2 indicated that the FAS of lake trout did reflect a diet switch, but this was also tissue specific. Our results underscore the importance of considering the biochemical makeup of the targeted sampling tissue and how strongly diet compositions are reflected in predator tissues when characterizing trophic interactions.

Casey Godwin[1], Subba Rao Chaganti[2], Gregory Dick[1], Ashley Elgin[3], E. Anders Kiledal[4], Doran Mason[3] and Edward Rutherford[3], [1]University of Michigan Cooperative Institute for Great Lakes Research, [2]University of Michigan, Cooperative Institute for Great Lakes Research, [3]NOAA Great Lakes Environmental Research Laboratory, [4]University of Michigan Earth and Environmental Sciences. **A Call for Monitoring and Tracking Biodiversity in the Laurentian Great Lakes.**

An important motivation for tracking and conserving biodiversity globally is the large body of research showing that species richness increases ecosystem functions (e.g., production, biomass) on a magnitude comparable to abiotic drivers. Recent national and international initiatives have directed urgent attention to standardizing and tracking biodiversity across global freshwaters, coasts, and the ocean owing to rapid loss and redistribution of species, interactions between biodiversity loss and anthropogenic stressors, and challenges of quantifying taxa in remote underwater environments. The inclusion of biodiversity among the drivers of community and ecosystem function has been slow to take hold in the Laurentian Great Lakes (LGL) and, despite comprehensive monitoring programs at different scales of biological organization, biodiversity and species richness are not routinely tracked or used to assess ecological change in this large and complex system. The lakes have lower richness than many marine ecosystems, particularly for animals, but without monitoring data we do not know where contemporary LGL communities reside on the biodiversity-function relationship and thus how sensitive those functions are to future changes in richness. Here we outline a new study on biodiversity in the LGL that leverages genomics, telemetry, and remote sensing and present an initial assessment of the role that biodiversity plays in comparison to other ecosystems. We also share a call for new collaborations to advance understanding and application of biodiversity for the LGL.

Enrique Gomezdelcampo[1], Oluwaseun Adeyemo[1], Priyanka More[2] and Dayal Wijayarathne[3], [1]Bowling Green State University, [2]South Carolina Department of Natural Resources, [3]University of Calgary. **Wet Prairie Restoration in a Great Lakes Watershed: A Comparison of Modeling Methods.**

In northwest Ohio, USA only a few wet prairies remain, most of them in the Oak Openings Region of the Maumee River watershed. These wet prairies are home to globally threatened wet prairie vegetation of conservation value and provide regional water quality services by filtering agricultural runoff from the surrounding landscape. The restoration of wetlands can be costly and time-consuming. Surface and ground water flow modeling can play an important role in the process of restoration and protection of wetlands. Modeling provides an opportunity to simulate the real behavior of both surface and ground water under various hydrological conditions, with each model having its own set of assumptions, limitations, and level of complexity. Three different methods were used to model the water table elevation of a wet prairie using hourly and daily datasets. These methods included GSSHA, a shallow groundwater-surface water interaction model; MODFLOW, a widely used and tested finite-difference, three-dimensional groundwater model; and NARX, a nonlinear autoregressive neural network with exogenous inputs model, a machine learning, data-based model. Results show that GSSHA and NARX are significantly better at predicting water table elevations than MODFLOW. Wetland restoration is currently being supported by natural resource management agencies for its conservation and regional water quality services. This study provides essential modeling for understanding management choices during the restoration of this significant ecosystem with implications to the health of the Great Lakes.

Xochitl Gonzalez[1], Michael Wagner[1], Roger Bergstedt[2], Maggie Jones[1] and Erick Larson[2], [1]Michigan State University, [2]USGS Hammond Bay Biological Station. **First observations of host finding behaviors of parasitic sea lamprey in the wild.**

Sea lamprey (*Petromyzon marinus*) is an invasive species of the Laurentian Great Lakes that parasitizes commercially and culturally valuable fishes, often resulting in death. Yet, because they are solitary, nocturnal, and cryptic, almost nothing is known about how they hunt for and acquire a host fish. From 2002 to 2005, 240 parasitic-phase juvenile sea lampreys were surgically implanted with data storage tags (DST) that recorded depth and temperature at intervals of 15 min and released into Lake Huron. Five of these were recaptured migrating into rivers 6-9 months later. Here, we present an examination of the early periods in those time series that correspond with parasitic feeding. We examined the data for characteristic changes in depth and temperature and compared them to vertical movement patterns consistent with various hunting strategies (e.g., lie-in-wait, active pursuit). We present hypotheses regarding how sea lamprey hunt for hosts and discuss the implications of these tactics for understanding the differing vulnerability of Great Lakes fishes to sea lamprey attack.

Malika Gottfried[1], Nikki Fuller[2], Nathan Eddingsaas[2] and Christy Tyler[2], [1]Smith College, [2]Rochester Institute of Technology. **Intercepting the Plastic Tide: Green infrastructure prevents downstream debris transport.**

Stormwater is a major pathway for the transport of plastic and other debris to waterways, but few studies have evaluated landscape level solutions in the built environment. Green infrastructure, such as bioretention areas and rain gardens, is an increasingly common solution to stormwater problems in urban areas, but the impact on debris transport is not well understood. We hypothesized that GI may act as a trap for both macro- and micro-plastic, therefore mitigating downstream plastic pollution. We measured accumulated debris in six bioretention areas around Rochester, NY, varying from urban to suburban, with land use ranging from commercial to mixed use. At each site, we collected all visible macrodebris (>5 mm) along with soil cores for microplastic (<5 mm) abundance. Macrodebris was categorized by use and material; plastic polymers were identified using FT-IR. Plastic was the most commonly found material at each site; packaging items such as duct tape and zip ties, as well as snack packaging and wrappers being the most common categories of debris found. Accumulation of both macro- and micro-debris was higher at urban sites and those with higher vegetation cover. Our findings offer valuable insights into the additional services provided by GI, suggest that intentional vegetative planting could assist with debris capture, and provide targeted insight into areas for cleanup efforts.

Theresa Gruninger, Ceci Weibert and Nichole Angell, Great Lakes Commission. **Great Lakes Aquatic Invasive Species Landing Blitz.**

The Great Lakes are continually threatened by the potential introduction, establishment and spread of new aquatic invasive species (AIS). The Great Lakes Aquatic Invasive Species Landing Blitz supports strategic advances in AIS education and outreach targeted to the recreational activities pathway of AIS introduction and spread. This project brings together state agencies and local volunteer partners to visit public and private boating access sites to deliver messaging about preventing the introduction and spread of AIS from the movement of watercraft and equipment between water bodies and has been a regionally coordinated event between U.S. states and Canadian provinces since 2019. Beginning in 2022, with an interjurisdictional AIS grant through the Great Lakes Restoration Initiative, the Great Lakes AIS Landing Blitz expanded its reach and activities by implementing small grant awards for local organizations to participate in the event and using digital

marketing strategies to advertise the event. A short marketing video was developed to advertise online, and geofencing, a process where a GPS polygon is drawn around boat launch sites and used to direct social media advertising to cell phones within the polygon, was deployed as a regional marketing strategy across high traffic boat launch locations in the Great Lakes. These methods result in unique and novel methods for AIS prevention and outreach, and signify the value of creativity when projects are supported via external funds.

Puwaner Guo, Jordan Bouchard and Amy Bilton, Department of Mechanical and Industrial Engineering, University of Toronto. **Comparison of Polyester Foams for Decanted Water Treatment in Oil Spill Response.**

Oil spills are a great environmental concern due to their toxicity and challenging recovery process. Skimming and decanting the collected water in a temporary storage vessel is being proposed as an alternative response measure in Canada; however, the decanted water often fails to reach the MARPOL's ANNEX 1 discharge oil content limit of 15 ppm. Recently, sorbents, such as polymer foams, have been proposed as a cost-effective strategy to remove the last traces of oil from oil-in-water emulsions with oil microdroplets (<20 μm). In this study, we developed two polyester polyurethane foams: one using unconventional azelate polyester polyol and another with commonly used adipate polyester polyol. The unconventional azelate polyester was chosen to increase the hydrophobicity of the foam. These two foams were compared against a commercially available acoustic polyester foam. It was found that both newly developed polyol foams outperformed the commercial acoustic foam in processing 80 L of an oil-in-water emulsion, with a 20% increase in oil removal efficiency. The performance difference between our two new foams was minimal: Incorporating the three extra carbon atoms in the polyurethane backbone by using azelate polyester polyol did not enhance the oil removal efficiency. This is significant because the conventionally used polyol is more commonly used and is more cost-effective. Balancing efficiency and practicality in manufacturing, the conventionally made foam could be a viable solution for decanted water treatment.

Jordan Gurneau[1], Chris McNerny[2], Jessica Strand[2], Ed Leoso[2], Joe Graveen[3], Raj Sankaran[4], Jonathan Gilbert[5], John Coleman[5], Brandon Byrne[5], Kathleen Smith[5], Josiah Hester[6], Kimberly Suiseeya[1], William Miller[1] and Aaron Packman[1], [1]Northwestern University, [2]Mashkiiziibii Natural Resource Department, [3]Lac Du Flambeau Band of Lake Superior Chippewa Indians, [4]Argonne National Laboratory, [5]Great Lakes Indian Fish & Wildlife Commission, [6]Georgia Institute of Technology. **Sovereign-Nation-Driven-Research of Annual Remote Wild Rice Habitats through Edge enabled AI/ML.**

Wild Rice (*Zizania palustris*) or Manoomin to Anishinaabe, or Psin to the Dakota people, is a culturally important plant relative and a sentinel species for wetland ecosystems in the Western Great Lakes. Manoomin provides a range of ecosystem contributions and is under threat due to ecological disturbances that occur throughout its annual lifecycle, including climate change, hydrological variability, disease, waterfowl herbivory, competition with invasive and native species, and anthropogenic water quality impacts. Advances in technology that utilize high-frequency data collection together with artificial intelligence and machine learning for data processing can supplement ongoing Indigenous stewardship of manoomin. We deployed the SAGE sensor platform in manoomin habitat, which provides *in-situ* data including imagery, temperature, and precipitation, and can integrate additional sensors for water quality parameters such as turbidity, electrical conductivity, and pH. We are using these tools to develop *in-situ* image detection to monitor phenological characteristics of manoomin and habitats such as overwintering data and

images for snow and ice presence, which is believed to be important for manoomin seed germination. Here we share the data currently being collected in natural manoomin habitat in the Kakagon River and Sloughs, an ecologically important estuary of Lake Superior. We then discuss how this sensor platform guided along with local expertise from Tribal Nations can provide insight into remote manoomin habitat and inform conservation of coastal ecosystems in the Great Lakes.

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Lloyd Haambiya[1], Craig Zytkow[1], Kabunda Malukutila[1], Peter Limbu[2], Lwabanya Mabo[3] and Mweemba Chijoka[4], [1]Frankfurt Zoological Society, [2]The Nature Conservancy, [3]Lake Tanganyika Research Unit, [4]National Policy and Planning. **A Pilot Approach Towards Managing the Commons of Lake Tanganyika: experiences and lessons.**

Arguably, fisheries of Lake Tanganyika operate under an open access regime. The fishery contributes to the welfare of riparian communities in terms of employment, wealth generation, social and cultural amenities, as well as food security. However, a socio-economic assessment revealed the absence of an effective Monitoring, Control and Surveillance system on the lake, leading to unregulated entry of fishers, use of destructive and illegal fishing gear, unprescribed and illegal fishing methods, low levels of compliance in acquiring fishing permits which has ultimately increased fishing pressure - resulting in decreasing fish biodiversity and production. In efforts to address this rampant tragedy of the commons on the fishery, Frankfurt Zoological Society (FZS) partnered with The Nature Conservancy (TNC) to pilot a community-led fisheries co-management approach in five fishing communities in Zambia. Under the support of the FZS-TNC project, governance structures were constituted, fisheries management zones and fish nursery grounds established, and capacity built in fish stock and fishing effort monitoring basics. While results of the interventions may be moderate, they provide valuable lessons for successful management of the Lake. Experience has shown that: it may take more than three years to organize and initiate activities and interventions at community level; partners require similar time to address concerns about legitimacy, trust, accountability and transparency; and co-management serves as a mechanism not only for fisheries management but also for community, economic and social development.

Michael J. Monfils[1], **Rachel A. Hackett**[1], Phyllis J. Higman[1] and Jeremiah Heise[2], [1]Michigan Natural Features Inventory, [2]Michigan Department of Natural Resources. **Plant and marsh bird relationships with invasive Phragmites australis occurrence and management in Saginaw Bay.**

Rapid expansion of invasive Phragmites australis in Great Lakes coastal wetlands has dramatically changed the ecosystem. To investigate the effects on areas invaded by Phragmites, we compared plant assemblages and marsh bird use among managed Phragmites, unmanaged Phragmites, and reference wetlands on Saginaw Bay. At 87 random points we sampled 840 0.25-m2 vegetation quadrats and conducted 760 marsh bird surveys. Multivariate ordination indicated separation of unmanaged points from managed and reference points, with similar plant assemblages among managed and reference points. Invasive Phragmites cover and density was similar between managed and reference points and both were less than that at unmanaged points. Diversity and floristic quality was lower at unmanaged points than other categories but similar between managed and reference points. American bittern, least bittern, common gallinule, marsh wren, and swamp sparrow abundances were lower in managed compared to unmanaged points. Pied-billed grebe and common gallinule were most abundant at reference points, whereas abundances of American

bittern, least bittern, Virginia rail, marsh wren, and swamp sparrow were similar between reference and unmanaged Phragmites. Occurrence of American bittern, least bittern, common gallinule, and marsh wren was positively associated with Phragmites cover, but Forster's terns had a negative relationship. Treatments during above-average water levels successfully reduced Phragmites but likely caused a short-term loss of nesting habitat for birds requiring dense vegetation.

Emily Hamilton, Cleveland Water Alliance. **Building the World's Largest Smart Lake.**

Cleveland Water Alliance has outfitted the Lake Erie Watershed with a state-of-the-art telecommunications infrastructure and hundreds of IoT sensors, making it the largest digitally connected freshwater body in the world. This network of sensors provides robust, real-time data to industry, utility, agriculture, maritime, research, and recreational interests across the region, enhancing their ability to provide functional, streamlined solutions for monitoring water quality in ever-changing conditions. This infrastructure includes low-power, low-cost, long-distance data transmission, supporting high volumes of IoT sensors and devices for the Initiative. Hundreds of sensors have been deployed across open water, beachfront, and river locations, as well as inland ponds, creeks, and streams, in order to provide a diverse and sophisticated data collection and decision support network. Through these resources, the program enables early warning and real-time insights for industry, utility, agriculture, maritime, and recreational interests.

Alice Hamisi, Aquaculture Specialist. **A Review of Gender Perspective of Women and Youth Involvement in Aquaculture along Lake Victoria, Kenya.**

Aquaculture is one of the fastest-growing sub-sectors with a huge potential for employing many people and solving food and nutritional security in Kenya. Men and women play different and shifting roles in aquaculture value chains, which are often diverse, complex, and dynamic. A value chain approach was undertaken to understand the role of women and youths in the industry. The study reviewed existing literature together with expert opinions, to evaluate the gender needs, approaches, and perspectives of this group's involvement in aquaculture along Lake Victoria, Kenya. The study reveals that women and youths are more involved at lower levels of the fishery value chain, where they have less access to resources and decision-making. Culture, values, and attitudes have a strong influence on access to aquaculture resources and control, technology adoption, and commercialization. However, this is not the case for women with higher education levels or access to resources. Men and youth, on average, are involved in production and harvesting while women invest more in processing equipment and are in charge of fish marketing. In conclusion, women and youth are still under-represented in aquaculture in Kenya. Addressing gender disparities by raising educational standards, increasing access to knowledge and technology, and increasing participation in decision-making could improve their capacities in aquaculture activities. Conversely, grants and loans that are directed to fish farmers should be gender-sensitive to ensure adequate involvement of vulnerable groups.

Tyler Hampton[1], Emma Cheriegate[2], Nandita Basu[1, 3] and Kimberly Van Meter[2, 4], [1]Department of Earth and Environmental Sciences, University of Waterloo, [2]Department of Geography, The Pennsylvania State University, [3]Department of Civil and Environmental Engineering, University of Waterloo, [4]Earth and Environmental Systems Institute, The Pennsylvania State University. **Using Remote Sensing to Quantify Wetland Restoration Potential in the Lake Erie Basin and Prairie Pothole Region.**

Wetland loss has devastated numerous ecoregions across Canada, including the Prairie Pothole Region (PPR) and the Great Lakes Basin: a region critical to water security on the

continental scale. Historical differences in the timing and severity of wetland destruction have resulted in areas of immense localized loss, like in Iowa, USA, where wetland loss exceeds 90%. Changes in policies related to the drainage of existing wetlands in both Canada and the USA increasingly put remaining, intact wetlands at risk. Smaller wetlands likely remain at greatest risk of loss. To begin addressing these challenges, we are exploring the ways in which human activities have altered the size distribution and spatial organization of wetlands over gradients of land use and management. Here, we present our methods for combining LIDAR remote sensing data, land cover, and wetland inventories to create an unprecedented, transboundary dataset of historical (drained) wetlands and measures of wetland loss. From these maps, we also present first steps towards development of a dataset of potentially restorable wetlands sites. As part of this work, we comment on differences in data availability and sources between the USA and Canada, and how to develop a regional analysis of this ecologically and economically important area of North America. A future regional inventory of drained and potentially restorable wetlands will be a critical tool for managing/restoring wetlands as a nature-based climate solution (NCS).

Patricia Hania, Toronto Metropolitan University. **Protecting Great Lakes freshwater, and communities from PFAS discharges from wastewater treatment plants.**

Canada needs to develop a sustainable, precautionary, integrated regulatory space for the discharge of PFAS from wastewater treatment plants (WWTP) that is protective of local communities. Currently, in Canada, at a federal and at a provincial level, the regulatory regime for a WWTP (i.e., *Wastewater Systems Effluent Regulation*s (2012)) does not include a discharge parameter for PFAS. Scientific research has shown that PFAS contaminated effluent is discharged from WWTPs into the Great Lakes waters that serve as a source of drinking water and habitat for fish, wildlife and microbiota. Despite the lack of PFAS discharge parameter for WWTPs, Canada has listed specific long-chain PFAS as toxic substances under the *Canadian Environmental Protection Act, 1999* (CEPA), the federal government's key pollution legislation. However, within the WWTP-PFAS regulatory space both a regulatory gap and a public health safety gap exists, which leaves the communities along the Great Lakes faced with a pressing chemical pollution problem: How to regulate WWTP-PFAS pollution discharges? This PFAS case study offers a comprehensive examination of the existing legislative frameworks applied to Canadian WWTPs and PFAS from an international, federal, provincial and municipal perspective, and argues for an integrated WWTP-PFAS regulatory space that upholds preventing harms to human and ecological health and shifts away from the legislated silo approach to pollution prevention relied upon in Canada.

Michael Hansen, Michigan State University. **Lake Trout Restoration in Lake Superior: A Branch in Bill Taylor's Academic Tree.**

Bill Taylor contributed to inland fishery management as my mentor and teacher, and thereby extended his influence through me to the Lake Superior Technical Committee, an interagency and international committee overseeing lake trout restoration in Lake Superior. Under Bill's leadership, my dissertation research included three important and timely contributions to lake trout restoration. First, at a time when most experts believed hatchery-reared lake trout could not reproduce, we showed that hatchery-reared lake trout were primarily responsible for population recoveries across Lake Superior. Second, before lake trout reproduced in other Great Lakes, we developed metrics for judging progress of lake trout recovery in Lake Superior, which were later used for judging success of lake trout recovery in Lake Superior. Third, we were the first to describe density-dependent declining survival of stocked lake trout in Lake Superior, eventually found to be a widespread phenomenon across all of the Great Lakes. The doctoral degree I earned under Bill's leadership

enabled me to move to academia, where I mentored undergraduate and graduate students, many of whom now work for state and federal fishery management agencies, and universities, as further branches in Bill's academic tree. In conclusion, Bill changed my life by nurturing me through a doctoral program, during which I learned how to mentor my own students, and by nurturing my research, through which he positively influenced management of Great Lakes fisheries.

Ethan Harrop[1], Nina Mueller[2], Luisa Fischer[3], Ryland Corchis-Scott[1], Mackenzie Beach[1], Qiudi Geng[1] and R. Michael McKay[1], [1]University of Windsor, [2]University of Hamburg, [3]Carl of Ossietzky University Oldenburg. **Environmental surveillance of antimicrobial resistance within the Huron-Erie corridor.**

The rapid increase in the prevalence of antimicrobial resistance (AMR) globally has caught the attention of governments worldwide. Overuse of antibiotics has driven the proliferation of drug-resistant organisms including carbapenemase-producing Enterobacterales (CPEs), which are of particular concern in Canada. Carbapenems are beta-lactam antibiotics that are used as a treatment of last resort to treat severe infections of multi-drug resistant bacteria. While many efforts are focused on clinical surveillance, there is growing emphasis on the importance of environmental reservoirs for AMR genes. We conducted preliminary research to assess prevalence of CPEs within the Huron-Erie corridor of the Great Lakes. This region receives treated wastewater effluent and combined sewer overflow from multiple wastewater treatment plants (WWTPs) along with substantial loading of agricultural contaminants from tributaries. Monitoring by qPCR focuses on two clinically relevant AMR targets, *Klebsiella pneumoniae* carbapenem resistant (KPC) beta-lactamases and New Delhi metallo-beta-lactamases (NDM). While we report high concentration of these genes in wastewater influent (KPC: 10^7 copies/L, NDM: 10^5 copies/L) and treated effluent (KPC: 10^3 copies/L), their abundance in receiving waters of the Detroit River and Lake St. Clair is variable. Persistent AMR has been measured near point sources of introduction with dilution of several orders of magnitude observed kilometers downstream. Contributions from WWTPs situated throughout the Huron-Erie corridor result in constant introduction of AMR potentially compromising the beneficial use of this important freshwater resource.

Tyler Harrow-Lyle[1], Ashley Elgin[2], Mark Rowe[2], Peter Aslip[3], Lyuba Burlakova[4], Alexander Karatayev[4], Reza Valipour[1] and David Depew[1], [1]Environment and Climate Change Canada, [2]National Oceanic and Atmospheric Administration, [3]University of Michigan, [4]SUNY Buffalo State University. **Comparing interpolation techniques for Dreissenid distributions across Lake Erie.**

Quagga and zebra mussels (*Dreissena rosteriformis bugensis* and *Dreissena polymorpha*) have been in Lake Erie since the early 1990's and late 1980's, respectively, and continue to negatively impact ecosystem functionality and services. Dreissenids are known to disrupt established nutrient pathways, especially within the littoral environment, change aquatic substrate structure, increase water clarity, and also increase the benthic production of the nuisance alga *Cladophora* spp. Mapping the distribution of dreissenids is essential for nutrient management, and are based on shell-free dry weight estimates which vary considerably in space and time due to environmental limitations such as depth, low oxygen conditions, and benthic sheer stress. Our goal was to compare several interpolation techniques which incorporate environmental limitations for dreissenids in an attempt to improve the current mussel maps used in nutrient management modelling. We compared several traditional interpolation techniques which do not incorporate environmental limitations (i.e., nearest neighbour, inverse distance weighting, ordinary kriging, and thin plate splines) to regression kriging approaches (i.e., random forest, generalized linear model, and general additive models) to determine

whether incorporating known environmental limitations increases the relative predictive capacity of dreissenids in Lake Erie. Most notably, the random forest regression kriging approach yielded the best relative performance for all methodologies investigated. Integrating the interpolated surface which incorporates known limiting environmental factors can improve current management attempts to assess dreissenid impacts to Lake Erie nutrient processes.

Tyler Harrow-Lyle, Andrew Bramburger and David Depew, Environment and Climate Change Canada. **Developing a novel dialysis array system to assess primary productivity along a nutrient gradient in Lake Ontario.**

Lake Ontario has exhibited sweeping food web changes since the 1970's, especially in higher trophic levels. Notably, the reduction in phosphorus loadings from the surrounding watersheds has led to declines in phytoplankton primary production and epilimnetic zooplankton communities. Recently, concerns have been raised about the ongoing disconnect between the eutrophic littoral and oligotrophic pelagic food web communities, with inadequate phosphorus concentrations limiting primary production being the suspected cause for the food web disconnect at higher trophic levels. We developed a novel dialysis array system for deployment in Lake Ontario to assess whether phosphorus concentrations were sufficient to support primary production along a nutrient gradient in Lake Ontario. The dialysis arrays were designed to try and remove common loss factors affecting plankton communities including grazing and sinking loss. Dialysis arrays were deployed at each sampling station in the littoral and pelagic zones and were retrieved after 7-14 days, weather and crew dependent. Our preliminary evidence demonstrates there was positive net growth for primary producers at all sampling locations, in both the littoral and pelagic zones. Sampling locations with higher phosphorus concentrations (i.e., near Toronto, Ontario, Canada) indicated light limitation for primary producer growth due to excessive surface blooms. Our initial results suggest that phosphorus concentrations are adequate for primary production, and intra and inter-specific food web interactions may be contributing to the disconnect between pelagic and littoral food web communities.

Lauren Hart[1, 2, 3, 4], Brittany Zepernick[4, 5], Kaela Natwora[4, 6], Katelyn Brown[3, 4, 7], Julia Akinyi Obuya[4, 8], Davide Lomeo[4, 9], Malcolm Barnard[4, 10, 11], Eric Owino[12], R. Michael McKay[3, 4, 13], Ken G. Drouillard[4, 13], David Sherman[2, 3, 14, 15], Greg Dick[3, 16, 17], George Bullerjahn[3, 4, 7] and 2022-23 NSF-IRES Lake Victoria Research Consortium[4], [1]Program in Chemical Biology, University of Michigan, [2]Life Sciences Institute, University of Michigan, [3]Great Lakes Center for Fresh Waters and Human Health, [4]2022-2023 NSF-IRES Lake Victoria Research, [5]Department of Microbiology, University of Tennessee Knoxville, [6]Large Lakes Observatory, University of Minnesota Duluth, [7]Department of Biology, Bowling Green State University, [8]Kenya Marine and Fisheries Research Institute, [9]Department of Geography, King's College London, [10]Department of Biology, Baylor University, [11]Center for Reservoir and Aquatic Systems Research, Baylor University, [12]Egerton University, [13]Great Lakes Institute for Environmental Research, [14]Natural Products Discovery Core, University of Michigan, [15]Medicinal Chemistry, University of Michigan, [16]Department of Earth and Environmental Sciences, University of Michigan, [17]Cooperative Institute for Great Lakes Research (CIGLR), University of Michigan. **Comparing Cyanobacterial Biosynthetic Potential Between Winam Gulf, Lake Victoria, Kenya and Western Lake Erie, USA.**

Cyanobacterial harmful algal blooms (cyanoHABs) are a growing global threat to potable water, human health, and wildlife. Excess runoff of nutrients fuel the overgrowth of cyanobacteria which can produce deadly cyanotoxins. *Dolichospermum* and *Microcystis* dominate expansive cyanoHABs in Western Lake Erie, USA (WLE) and the Winam Gulf (i.e., Nyanza Gulf) of Lake

Victoria, Kenya. These shallow basins are similar in their bathymetry, proximity to human populations, and anthropogenic inputs of nitrogen and phosphorus, fueling dangerous cyanoHABs. Here, we use metagenomics to identify the genomic and biosynthetic potential of the main cyanobacterial bloom-formers in these basins over a spatiotemporal gradient. We identified similar biosynthetic potential across the two basins, encoding a diverse and potentially hazardous array of specialized metabolites. Additionally, phylogenomic analyses indicate genomic similarity between representative *Microcystis* and *Dolichospermum* species in the two great lakes. These results are vital and initial metagenomic insights into cyanoHABs in the Winam Gulf and provide invaluable comparisons to a hydrologically similar yet distinct basin, WLE. Furthermore, the Winam Gulf serves as a unique glimpse into how rising global temperatures may alter cyanoHAB communities in a warming (temperate) WLE. Future work is needed to better understand the complex dynamics of cyanoHABs in the Winam Gulf and how they compare to cyanoHABs around the world. Such global comparisons will improve understanding of ecological and biosynthetic aspects of cyanoHABs enabling better predictions and management.

John Hartig, University of Windsor, Great Lakes Institute for Environmental Research.
Exemplars of ecosystem-based management.

An ecosystem approach accounts for the interrelationships among air, water, land, and all living things, including humans, and involves all user groups in comprehensive management. Ecosystem approaches are frequently designed for a particular place and a particular set of stakeholders. As such, they are frequently referred to as locally designed ecosystem approaches. Key elements of an ecosystem approach include: bringing stakeholders together; defining a desired future state or vision that can be carried in the hearts and minds of all stakeholders; building capacity; ensuring human and financial resource support; co-producing knowledge; co-innovating solutions; and practicing adaptive management where assessments are made, priorities established, and actions taken iteratively for continuous improvement. In the Great Lakes basin, an ecosystem approach and ecosystem-based management now have a 50-year history of understanding ecosystems and managing relationships between humans and their ecosystems. Three exemplar case studies of ecosystem-based management will be presented: Don River naturalization in Toronto, ON, Detroit RiverWalk in Detroit, MI, and Hamilton Harbour's Randle Reef in Hamilton, ON. Based on experience from the Great Lakes basin, it would be prudent to prioritize the development of boundary spanners - individuals who establish "bridges" within and outside an organization who can help serve as facilitators, knowledge brokers, and champions of strengthening science-policy-management linkages.

Kit Hastings and Susan Daniel, Buffalo State University. **Oligochaete community of Lake Huron.**

Oligochaete worms are important indicators of water quality and the health of the lower trophic community. We examined the oligochaete community of Lake Huron as a part of the 2022 Cooperative Science and Monitoring Initiative (CSMI) survey. Samples were collected from 147 stations using a Ponar dredge and identified to species where possible. In total, oligochaetes contributed 49% of the total abundance of all benthic macroinvertebrates in Lake Huron, yet only contributed 1.2% of lakewide biomass. Within our study we identified 47 taxa, and the Main Basin (37 taxa) was most diverse, followed by Saginaw Bay (33), North Channel (31), and lastly Georgian Bay (26). Overall, the most abundant species was *Spirosperma ferox* (15.8% of total Oligochaeta), followed by *Stylodrilus heringianus* (6.4%), *Potamothrix vejdovskyi* (6.0%), and *Limnodrilus hoffmeisteri* (3.5%). In Saginaw Bay, the most abundant were *Aulodrilus pluriseta*, *A. pigueti*, and *A. limnobius*. By

family, Tubificinae was the most abundant (67.2% including immature) and diverse (25 species), followed by Lumbriculidae (23.3% including immature) which was represented by one species, and Naidinae (7.2%) which was the second most diverse family (20 species). Conversely to the other regions, North Channel had proportionally more Naidinae (16) species than Tubificinae (13). The dynamic habitats of Lake Huron and its embayments result in complex benthic communities worth exploring via the diverse group Oligochaeta.

Eden Hataley[1], **Rebecca Rooney**[2], Karen Kidd[3], Chelsea Rochman[4], Austin Baldwin[5], Carlie Herring[6], Dale Hoff[7], Francois Houde[8], Carl Platz[9], John Bratton[10], Samir Qadir[11], Lizhu Wang[12] and Matthew Child[12], [1]University of Toronto Scarborough, [2]University of Waterloo, [3]McMaster University, [4]University of Toronto, [5]United States Geological Survey, [6]National Oceanic & Atmospheric Administration, [7]US EPA, [8]Ministère de l'Environnement et de la Lutte contre les changements climatiques, de la Faune et des Parcs, [9]US Army Corps of Engineers, [10] LimnoTech, [11]Potomac-Hudon Engineering, [12]International Joint Commission. **Developing frameworks for monitoring and assessing the ecological risk of microplastics in the Great Lakes.**

Plastic pollution, particularly microplastics, is widespread across the Laurentian Great Lakes basin. The International Joint Commission (IJC) has been addressing the issue since 2015. Past efforts developed a *Microplastics Watching Brief* to summarize points of interest related to microplastics science, policy, and media; and recommendations for addressing challenges posed by microplastic pollution across the region. Most recently (early 2023), the IJC's Science Advisory Board formed a working group on microplastics comprised of subject matter experts from Canada and the United States. The objective of this working group is to develop coordinated frameworks for microplastics monitoring and ecological risk assessment and management for use in the Great Lakes region. The working group has completed: (1) drafting a literature review to synthesize recent scientific advances in understanding microplastic pollution in the Great Lakes and identifying knowledge gaps; (2) updating databases to include relevant freshwater microplastic environmental contamination and ecological effects studies; (3) hosting a workshop to develop recommendations for harmonized guidelines for sampling microplastics on shorelines and in water, sediment, and biota for the design and implementation of a Great Lakes-specific monitoring program; and (4) hosting a workshop to develop recommendations for an ecological risk assessment and management framework that would contextualize monitoring results and recommend corresponding management actions. This presentation will provide details about the objectives and progress in the context of Great Lakes science needs and strategic priorities.

Evan Lucas, Chris Pinnow and **Timothy Havens**, Michigan Technological University. **Surface Current Prediction in the Straits of Mackinac Using HF Radar.**

In 2019, the very first operational high-frequency radar was deployed in the Great Lakes, at the Straits of Mackinac. Since then, the system has provided continuous, publicly-available surface current data for the region to the immediate west of the Mackinac Bridge, supporting the significant potential for the use of HF radar to provide reliable current measurements in freshwater. In this talk, we will give a background on the system, show analysis that compares current measurements from co-located observational buoys, and demonstrate a novel machine learning method that processes historical spatiotemporal current measurements to predict future currents. Future ideas for Great Lakes HF radar installations will also be discussed.

Todd Hayden[1], Chris Holbrook[2], David Fielder[3], Tom Binder[1] and Aaron Fisk[4], [1]Michigan State University, [2]US geological Survey, [3]Michigan Department of Natural Resources, [4]School of the Environment, University of Windsor. **Habitat use of cisco along a nearshore-offshore gradient in Northern Lake Huron.**

Movement and behavioral ecology of Cisco *(Coregonus artedi)* populations in the Great Lakes are poorly understood. Cisco populations in Lake Huron experienced large scale extirpation and range reduction during the early 1900's as a result of establishment of invasive species, habitat destruction, and overexploitation. Populations have since failed to recover and a restoration program focused on stocking hatchery-reared fish in Saginaw Bay was implemented. Here we report on the findings of a study that used acoustic telemetry to characterize movement and habitat use in the Les Cheneaux Islands region of Lake Huron. Study objectives were to describe post-spawning movements and habitat use within the Les Cheneaux Islands and nearshore region of Lake Huron, estimate the degree of spawning site fidelity to the Les Cheneaux Islands, and determine the timing and spatial extent of post-spawning movements. Results suggested that cisco inhabited nearshore waters within the Les Cheneaux Islands during winter and spring and moved offshore to deeper water in Lake Huron during summer and autumn. Cisco suspended 8-20 meters below the surface during summer and autumn and experienced water temperatures from close to 0 degrees C to 12 degrees C. This study provided direct observation of the extent and timing of movements between the Les Cheneaux Islands and nearshore regions of Lake Huron and is critical for determining when and where cisco should be stocked to achieve restoration goals.

Daniel Hayes[1] and Jason Smith[2], [1]Michigan State University, [2]Bay Mills Indian Community. **Bill Taylor's Impact on Inland Fisheries Management.**

Through his research, teaching, leadership and mentoring, Bill Taylor has directly and indirectly shaped the careers and path of fisheries management in the Great Lakes region and beyond. Bill's direct influence has perhaps been greatest through his inspiration of his mentees for excellence, but this impact has multiplied through this extensive "academic family". In terms of his contributions to fisheries management, one of the lessons I (DH) learned early is what he terms the 8-steps of management. A quick outline of these steps is set goals, evaluate situation, set objectives, prescribe treatment, organize resources, implement, evaluate, and maintain. Although these steps seem quite straightforward and easy to follow, we have observed that the early step of setting objectives is often very challenging and one that often gets bypassed. In this talk we will elaborate on why this step is perhaps most critical, and the legacy Bill has left emphasizing an iterative stepwise process for fisheries management.

Issac Hebert and Erin Dunlop, Ontario ministry of natural resources and forestry. **Variation in the feeding success of larval lake whitefish from Lake Huron.**

Lake whitefish (*Coregonus clupeaformis*) populations have been declining in many regions of the Laurentian Great Lakes. This has led to heightened interest in the feeding ecology of young lake whitefish, as reduced food availability during early life is believed to be contributing to recruitment declines. Understanding factors driving feeding success (the successful capture of prey), is crucial as it can impact growth and survival. This study aims to examine factors driving the feeding success of larval lake whitefish and determine if there is an association between feeding success, growth rates, and survival. Larval fish were collected from the Fishing Islands spawning shoal complex in Lake Huron from 2017 to 2022 using pelagic trawls during the spring. Fish were genetically identified, and their digestive tracts were extracted, and contents were enumerated and measured. Feeding success was estimated using the residuals from the relationship of the amount consumed by fish length. We

found that feeding success showed annual variation with some evidence of the variation being driven by density dependent mechanisms and prey choice. We also show a positive correlation between annual estimates of feeding success with food abundance, growth rates, and survival. These results suggest that growth and survival of larval fishes is associated with the ability of these young fish to continuously feed successfully and that multiple mechanisms can influence feeding success.

Paul Helm, Nadine Benoit and Todd Howell, Ontario Ministry of the Environment, Conservation and Parks. **Perfluoroalkyl substances in urban-impacted watersheds and nearshore waters of Western Lake Ontario.**

Per- and polyfluoroalkyl substances (PFAS) are widely occurring contaminants throughout the Great Lakes environment and, although several PFAS substances (e.g., perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA) and other long-chain perfluorocarboxylic acids) are regulated in Canada, many remain in widespread use. To access the current state of inputs to and levels in Lake Ontario, seven Greater Toronto Area watersheds were sampled for PFAS in 2022 and 2023 upstream of their outlets to Lake Ontario during wet weather and dry weather flows. Nearshore lake waters primarily in western Lake Ontario were sampled in 2023. In streams, the shorter chained perfluorocarboxylic acids, including perfluorobutanoic acid (4.6-7.6 ng/L), perfluoropentanoic acid (3-12.5 ng/L), and perfluorohexanoic acid (2.5-9.6 ng/L), as well as PFOS (1.3-10.1 ng/L), were most prevalent. This is a shift from the dominance of the longer chained compounds, mainly PFOS and PFOA, observed in the same streams in 2006-07 prior to regulation. The highest concentrations of most PFAS parameters were in Etobicoke Creek, which contains the international airport and where there have been past spills of PFAS-containing fire-fighting foams. Similar PFAS profiles were observed in Lake Ontario. Notably, concentrations of PFOS and PFOA have continued to decline after regulation. For example, PFOS concentrations (mean +/- standard deviation) declined from 7.3 +/- 2.2 in 2006 to 2.6 +/- 0.9 in 2018 and 1.7 +/- 0.8 ng/L in 2023.

Matt Herbert[1], Jason Smith[2], Dave Clapp[3], D.J. Smith[4], Rusty Aikens[4], Kris Dey[5], Gary Michaud[5], Ben Turschak[3], John Bauman[3], Emily Martin[3], Troy Zorn[3] and Jamie Dobosenski[1], [1]The Nature Conservancy, [2]Bay Mills Indian Community, [3]Michigan DNR, [4]Sault Tribe of Chippewa Indians, [5]Little Traverse Bay Band of Odawa Indians. **Evaluating the distribution of Lake Whitefish tributary spawning runs and the potential to restore them.**

Lake Whitefish spawn on Great Lakes rocky reefs. But historically they also spawned in large numbers in Great Lakes tributaries. The impacts of logging and mill dams reduced these spawning runs to near zero levels by the early 1900s. In recent years, Lake Whitefish spawning runs have re-established in several Wisconsin tributaries of Green Bay. Re-established tributary spawning runs can help to increase production and provide increase population stability. We hypothesized that Lake Whitefish spawning runs have also likely returned to some Michigan tributaries of Green Bay, but not to tributaries elsewhere. To that end, we began conducting late fall electrofishing surveys in 2018 in Michigan tributaries of Green Bay, northern and eastern Lake Michigan and northern Lake Huron. We have successfully documented Lake Whitefish spawning runs in Green Bay tributaries in Michigan, but nowhere else in Lake Michigan or Northern Lake Huron. Based on the success of naturally re-established spawning runs in Green Bay, we believe that restoration of spawning runs elsewhere can help in rebuilding diminished Lake Whitefish populations in areas of Lake Michigan and Lake Huron. Starting in 2022, we have begun experimental efforts to develop and test approaches for restoring Lake Whitefish spawning runs in tributaries.

Maria D Hernandez Limon[1], Justin Podowski[2], Sara Paver[1] and Maureen Coleman[1], [1]University of Chicago, [2]Argonne National Laboratory. **Drivers of free-living and particle-associated prokaryotic community structure in the Laurentian Great Lakes.**

The range of biogeochemical gradients in the Laurentian Great Lakes, in addition to the Lakes' rapid warming, make the system a natural laboratory for studying microbial biogeography under climate change. Here we present an eight-year timeseries of 16S rRNA sequencing from both free-living and particle-attached prokaryotic communities, collected across the five Great Lakes during episodic spring and summer sampling - totaling over 1600 samples. We find that water strata associated with thermal stratification harbor distinct microbial communities, even in conditions of inverse stratification where the strata differ in temperature by only ~2 degrees. We find different environmental drivers of community composition based on the spatial/temporal scale we examine, ranging from strong strata/lake/year effect when looking at the whole basin, to specific environmental variables within a lake or strata. We find that the free-living community is less diverse than the particle-attached community and more sensitive to environmental change. We find the structure of the prokaryotic community, the environmental drivers, and the effect of those drivers differ between size fractions. Together, our results demonstrate how environmental factors influence the community structure of prokaryotes in the Great Lakes and quantify year-to-year variability over 8 years. This baseline understanding is critical for detecting future changes and trends driven by climate change.

Taylor Herne[1, 2], Lars Rudstam[1, 2], James Watkins[1, 2], Sarah Lawhun[1, 2], Patrick Boynton[1], Alexander Karatayev[3, 4] and Lyubov Burlakova[3, 4], [1]Cornell University, [2]Cornell Biological Field Station, [3]Buffalo State Great Lakes Center, [4]Buffalo State. **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 both a prey item for numerous fish species and as a predator for smaller zooplankton in the water column. Mysis spend much of their time during the day on the benthic floor, then during the night migrate from the benthic into the pelagic, forming a distinct layer near the thermocline, though there are known deviations to this behavior. Long-term monitoring efforts of Mysis in the Great Lakes focus solely on population abundance estimates calculated from nighttime whole water column net tows. This net based monitoring has suggested a recent decline in the Mysis population of Lake Michigan 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 mysid 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 Mysis benthic habitat utilization. Concurrent drop-down camera videos were taken at all sites and were used confirmed these benthic abundance estimates and provide unique insight into mysid behavior on the benthic floor.

Max Herzog, Cleveland Water Alliance. **Lake Erie Baseline Assessment Framework: Telling a Community-Driven Story about Lake Erie Watershed Health.**

Historically, volunteer water quality monitoring 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 into a cohesive movement capable of elevating the quality of their data. Over the next three years, the Network created and piloted the Lake Erie Baseline Assessment Framework (LEBAF), a standardized approach to volunteer-driven water data

collection, analysis, and reporting. Through technology and collaboration, LEBAF empowers individual communities to advocate for their local waterways while allowing them to integrate their data at the regional level to tell a shared story about the health of Lake Erie Watersheds. Since its founding, LEVSN participation has more than doubled and the network has partnered with key decision makers to refine LEBAF and work towards filling critical data gaps that inform management efforts at the local, regional, and Great Lake levels. Now, as our second year of fully standardized data collection and reporting wraps up, we can share reflections on the progress we have made and how others can build on the model we have piloted.

Cecilia Heuvel[1], Aaron Fisk[2] and Yingming Zhao[1], [1]Ontario Ministry of Natural Resources and Forestry, Aquatic Research and Monitoring Section, [2]School of the Environment, University of Windsor. **The impact of invasive species on Lake Erie walleye and yellow perch: Ecopath modelling.**

Aquatic food webs are dynamic, and relationships between species are perpetually changing as organisms adapt to current environmental conditions. Here, we investigate how the structure and function of the Lake Erie food web has changed over the past 20 years using mass balanced Ecopath models representing two different time periods: 1998-2002 and 2016-2020. The first period covers two important species invasions, *Dreissena* spp. and the round goby (*Neogobius melanostomus*), and the second 20 years post invasions. Between 1998-2002 and 2016-2020, walleye (*Sander vitreus*) biomass increased while yellow perch (*Perca flavescens*) biomass decreased in conjunction with decreases in *Dreissena* spp. and increases in round goby biomasses. Importantly, trophic transfer efficiency in the Lake Erie food web has increased since the late 1990's. However, this has not helped yellow perch populations suggesting that trophic pathways have been altered. This modelling exercise has demonstrated that the long-term influence of two large species invasions has had variable impacts on key fish species within Lake Erie.

Benjamin Hlina[1], Tim Johnson[2] and Aaron Fisk[1], [1]University of Windsor, [2]Ontario Ministry of Natural Resources and Forestry. **Temporal and spatial changes in isotopic trophic niches for multiple fish guilds in Lake Ontario.**

Over the last decade offshore productivity has declined in Lake Ontario, however, the causes and consequences of these changes are not fully understood. Multiple anthropogenic disturbances (e.g., nutrient loading, development, climate change, and invasive species) have affected and continue to affect planktonic and benthic resources that multiple trophic levels (e.g., forage fishes, salmonids, and cool- and warmwater species) rely on. For example, recent reports and studies demonstrate temporal and spatial variation in isotopic signatures of alewife (*Alosa pseudoharengus*). These results suggest alewife have regionally specific diets that might consist of limited prey resources and/or nutrient content that could affect the stability of alewife populations and have consequences (e.g., interspecific competition) for upper trophic levels (e.g., salmonids). Investigating temporal and spatial changes in isotopic niches provides information about changes in resource allocation, niche partitioning, and species and system responses to disturbances. Therefore we used $\delta^{13}C$ and $\delta^{15}N$ samples collected from 2008 to 2022 from multiple species at multiple trophic levels (i.e., plankton, forage fishes, cool-and warmwater fishes, and salmonids) to investigate whether temporal and/or spatial changes in multiple resources affect niche size and similarities, resource allocation, and responses to disturbances. Results generated from our analysis provides context on how ecological shifts in Lake Ontario are potentially influencing fish community structures and population dynamics. By understanding variation in trophic dynamics, fisheries management and conservation efforts can effectively be applied in Lake Ontario.

Grant Hodgins[1], Clare Robinson[1] and James Roy[2], [1]Western University, [2]Environment and Climate Change Canada. **Investigating the influence of groundwater discharge on the salinization of urban streams.**

Salinization of fresh surface waters due to elevated chloride (Cl) is a major and increasing threat to aquatic ecosystems. Increasing summer Cl concentrations in urban streams suggest that groundwater discharge could be an increasingly important pathway delivering Cl to streams but the contributions of groundwater discharge including factors controlling its variability are not well quantified. The objective of this study was to evaluate the role of groundwater in delivering Cl to urban streams of varying size and geology at the watershed scale including understanding the spatial and temporal variability of these inputs. This was conducted through longitudinal monitoring of groundwater tracers and Cl concentration along four urban freshwater streams of varying size, land use, and geology throughout the year. Groundwater discharge had a direct influence on Cl concentrations in the smaller streams with more permeable lithology. In one small stream, groundwater discharge was linked to an increase in Cl concentration from 500 to 2000 mg/L along 500 m during summer baseflow conditions. In the larger streams, increases in baseflow groundwater signatures and Cl concentrations were more gradual, e.g., an increase in Cl of 100 mg/L over 2000 m. This study shows that groundwater inputs of Cl to streams can lead to year-round elevated Cl concentrations in freshwater urban streams and highlights the need for better practices to reduce road salt infiltration into urban groundwater systems.

Haley Hoehn[1], Laura Johnson[1, 2], Jakob Boehler[1, 2] and Kelly Peterson[1], [1]Heidelberg University, [2]NCWQR. **Quantifying Primary Algal Groups in H2Ohio Wetlands.**

Since 2020, the state of Ohio has invested in the construction of 141 wetlands as a part of the H2Ohio Program with the primary goal of nutrient reduction. Algae, found either in the water column or benthos of a wetland, play an important role in nutrient removal. In order to better quantify wetland ecosystem functioning, it is important to understand the temporal and spatial dynamics of major algal groups. Both phytoplankton and periphyton concentrations were measured across nine H2Ohio wetland sites in the summer of 2023. Grab samples were collected to measure phytoplankton concentrations and unglazed ceramic tiles were deployed to measure periphyton concentrations. All samples were run on a bbe FluoroProbe. We also quantified potential drivers of algal composition, such as depth, temperature, and vegetation coverage. While the composition of algal groups were highly variable across wetlands, we found green algae was the primary algal group for both phytoplankton and periphyton. There was no clear relationship among the expected potential drivers and the algae concentrations measured. Future studies should also include the testing of the input and output bodies of water such as streams, creeks, and rivers. Algae is important in wetlands because of its ability to assimilate nutrients such as nitrogen and phosphorus. In others, where water depth and vegetation has prohibited growth, other biological processes, such as other vegetation or bacteria, are likely more important.

Rob Stewart and **Tim Hollinger**, Lakehead University. **Are The Fish Safe to Eat? An Examination of Lake Nipigon Fish Consumption Guidelines Through the Perspective of Biinjitiwaabik Zaaging Anishinaabek.**

Mercury (Hg) is a contaminant of concern when consuming fish from freshwater lakes. It is known to persist in high concentrations in piscivorous fishes such as Walleye which are commonly consumed by people. The people from the community of Biinjitiwaabik Zaaging Anishinaabek (BZA) Rock Bay have harvested fish from the Lake Nipigon basin for millennia and have observed changes to the Lake, particularly those resulting from resource development and extraction. Large

scale hydroelectric projects and mining have created concerns over the safety of eating Walleye in the Lake Nipigon basin from traditional fishing locations. While fish consumption guidelines are posted by the provincial government for certain areas, a lack of robust data, trust, transparency and communication about the risks of exposure to consumers has rendered these guidelines largely ineffective for community use. In this study, data collection was led by community fishermen at traditional fishing locations to produce community driven fish consumption guidelines. In general, fish consumption guidelines produced from community sampling were less restrictive than those posted by the provincial government where comparable. However, community-based fish consumption guidelines were more restrictive in riverine environments than lake sampling locations. As a result of having engaged in data collection and monitoring for fish contaminants, BZA has developed greater trust and interest in fish consumption guidelines while greatly enhancing its lands and resources program to further study concerns on Lake Nipigon.

Steve Holysh, Richard Gerber, Mason Marchildon, Mike Doughty, Steve Shikaze and Britt Smith, ORMGP. **Groundwater insights within Lake Ontario's north shore catchment.**

The Oak Ridges Moraine Groundwater Program (ORMGP) is a partnership of 15 government agencies working collaboratively to collect, manage, and analyse groundwater data, and then to disseminate, via an interactive web portal, a comprehensive understanding of the groundwater system along much of the north shore of Lake Ontario. The program's database now exceeds 100 gigabytes and the estimated value of the holdings is on the order of $1 billion. A significant component of the program is the custodianship of 90 numerical groundwater flow models that have been completed across south-central Ontario. Despite their sophistication, the high costs involved in their development, and the insights that are attained from these models, these tools are commonly used only once in Ontario. This is owing to their complexity and the limited number of proficient numerical modelers available. To improve accessibility and overall use of numerical models in decision-making, the ORMGP now makes modelling results readily available through an interactive web portal. For example, the ability to dynamically click on a map and visualize forward and reverse particle tracking allows users to see, for example, from where groundwater discharge to any reach of stream or lake shoreline might originate. When coupled with mapping of the water table configuration and statistical analysis of observed flow (e.g., streamflow), the availability of particle tracking provides a powerful tool to gain valuable insights towards flow system understanding.

Darryl Hondorp[1], Jason Smith[2], Erik Olsen[3] and Ben Turschak[4], [1]USGS, [2]Bay Mills Indian Community, [3]Grand Traverse Band of Ottawa and Chippewa Indians, [4]Michigan Department of Natural Resources. **Lake Whitefish spawning behavior and habitat selection in northeast Lake Michigan.**

Persistent low recruitment has contributed to declines in abundance and harvest of Lake Whitefish (LWF), *Coregonus clupeaformis*, in northern Lake Michigan, so fishery managers are interested in actionable strategies for improving the survival of LWF eggs, larvae, and juveniles. Protection and restoration of spawning habitat has been identified as a potential management option for addressing declining LWF recruitment, but LWF spawning behavior and habitat selection is poorly understood. In this study, we describe and compare movements of habitat use of acoustic-tagged LWF on two known spawning reefs in northeast Lake Michigan. Study objectives were to identify the specific microhabitat characteristics (e.g., slope, aspect, substrate size, mussel cover) that best predict the distribution of spawning whitefish on reefs, and then to determine if LWF spawning behavior varies between spawning reefs that differ in size, shape, distance from shore, and

morphology. Study results showed that LWF use of spawning reefs is restricted to relatively small areas of available reef habitat characterized by specific combinations of substrate and slope, information that managers can use to improve the quality and effectiveness of future spawning habitat restoration projects and to designate areas for protection. However, our study also provided evidence that LWF spawning habitat selection and behavior can differ significantly among even closely-located spawning populations.

Yi Hong[1], Lauren Fry[2], Dani Jones[1] and Andrew Grounewold[3], [1]Cooperative Institute for Great Lakes Research, University of Michigan, [2]National Oceanic and Atmospheric Administration, Great Lakes Environmental Research Laboratory, [3]School for Environment and Sustainability, University of Michigan. **Trend and variability in hydro-meteorological extremes of water balance components for the Great Lakes.**

Recent extreme fluctuations in Great Lakes water levels emphasize a growing need for accurate prediction of water level changes for adaptive water management. Despite advancements in hydro-meteorological observation and modeling, a better understanding of trends and variability in extremes of water balance components is needed. Changes in the water level of a lake are mainly dependent on the net basin supply (NBS), which considers factors such as over-lake precipitation, evaporation, and total runoffs entering the lake from its drainage basin. Based on a recently developed dataset that includes daily records of water balance components for the Great Lakes since 1979, we can perform a detailed trend and variability analysis of NBS and its components over the Great Lakes. The coefficient of variation and Mann-Kendall methods are used to analyze the variability and trend of the daily Maximum and Minimum of different variables for each of the Great Lakes, respectively. In addition, we also investigate correlations between extremes of daily NBS components with monthly and quarter-monthly water levels. The findings of this study can serve as critical tools for sustainable and adaptive water management and guide the development of the next-generation water level forecasting system for the Great Lakes.

Tomas Höök[1], Paris Collingsworth[1], David Fielder[2] and Steven Pothoven[3], [1]Purdue University and Illinois-Indiana Sea Grant, [2]Michigan Department of Natural Resources, [3]NOAA Great Lakes Environmental Research Laboratory. **Applied Research Informing Management and Recovery of the Saginaw Bay Fish Assemblage.**

Saginaw Bay, Lake Huron, has historically supported a wealth of commercial and recreational fisheries. However, for at least a hundred years the fish stocks underlying these fisheries have been threatened by various anthropogenic stressors including excessive nutrient loading, invasive species, overfishing, chemical contamination and habitat loss. In 2007, NOAA's Great Lakes Environmental Research Laboratory (GLERL) and partners initiated a large project, "Adaptive Integrated Framework (AIF): a new methodology for managing impacts of multiple stressors in coastal ecosystems," with a partial aim of elucidating anthropogenic stressors on Saginaw Bay fish stocks and informing management of the system. We will present key findings of this project related to Saginaw Bay fish populations and assemblages. Further, we will describe various follow-up studies on Saginaw Bay fish stocks, including on-going efforts to restore and assess rocky reef habitat in Saginaw Bay. In so doing, we aim to highlight not only direct contributions by GLERL, but also how GLERL collaborations helped catalyze subsequent research projects and training opportunities for post-docs, graduate and undergraduate students.

Minmin Niu[1], Chengjing Li[2], **Xiuli Hou**[1], Wenyu Long[1] and Xuexiu Chang[2], [1]Yunnan Collaborative Innovation Center for Plateau Lake Ecology and Environmental Health, College of Agronomy and Life Sciences, Kunming University, [2]Great Lakes Institute for Environmental Research, University of Windsor. **Response of an endangered macrophytes to co-occurring cyanobacterial bloom and invasive fish.**

Submerged microphytes play a crucial role in aquatic ecosystems, facing challenges from cyanobacterial harmful algal blooms (cHABs) and invasive fish. *Microcystis aeruginosa* is a common dominant species of cHABs, while *Pseudorasbora parva* is classified as an invasive alien fish. These two stressors coexist in Dianchi Lake (China), which was once dominated by the native macrophyte *Ottelia acuminata*. However, *O. acuminata* disappeared from the lake decades ago and is now classified as an endangered plant. To understand how these dual stressors affect the reintroduction of *O. acuminata* to Dianchi Lake, we conducted mesocosm experiments, co-culturing *O. acuminata* with *M. aeruginosa* and *P. parva*. We found that: 1) both individual and combined exposures to *M. aeruginosa* and *P. parva* significantly reduced the biomass and chlorophyll content of *O. acuminata*, with the combined stress causing more pronounced inhibition and greater damage than individual stress; 2) *M. aeruginosa* and *P. parva*, individually or in combination, significantly increased the levels of soluble sugars, tannins, and total phenols in *O. acuminata*, with markedly higher content under combined stress; 3) *M. aeruginosa* treatment elevated the flavonoid content in *O. acuminata*, which was further intensified by the co-occurrence of *P. parva*, although no significant change was observed under *P. parva* alone. These findings contribute valuable knowledge for the protection of native plants in lakes under multiple stressors.

Kelly Hoyer[1], Tracy Galarowicz[1], Jory Jonas[2], Ellen Marsden[3], Kevin Pangle[1], Jason Smith[4] and Scott McNaught[1], [1]central michigan university, [2]Michigan Department of Natural Resources, [3]University of Vermont, [4]Bay Mills Indian Community. **Vulnerability of Larval and Juvenile Lake Whitefish (*Coregonus clupeaformis*) and Cisco (*C. artedi*) to Introduced Nearshore Predators Round Goby (*Neogobius melanostomus*) and Rainbow Smelt (*Osmerus mordax*).**

Lake Whitefish (*Coregonus clupeaformis*) have been experiencing a downward recruitment trajectory in northern Lake Michigan. Cisco (*C. artedi*), on the other hand, have been experiencing a higher recruitment trajectory in the same region. Difference in recruitment levels between these two species may begin at the larval or juvenile stage due to different avoidance behaviors in response to introduced nearshore predators, Round Goby (*Neogobius melanostomus*) and Rainbow Smelt (*Osmerus mordax*). We tested the predation success of Round Goby and Rainbow Smelt on both larval and juvenile Lake Whitefish and Cisco at various sizes using controlled foraging experiments to compare predation behaviors on and avoidance patterns of the two coregonine species. Medium and large Round Goby exhibited higher captures and/or predation efficiency on Lake Whitefish than Cisco in medium and large size categories. While Rainbow Smelt exhibited no difference in captures between either prey species at any size, attacks per pursuit by Rainbow Smelt were higher of large age-0 Lake Whitefish than Cisco. Larval Cisco exhibited tighter group cohesion than larval Lake Whitefish, which could contribute to lower predation success and/or efficiency by Round Goby and Rainbow Smelt. Our results suggest that Round Goby (>65 mm) may have an impact on 20-30 mm age-0 Lake Whitefish recruitment, and Rainbow Smelt may have a bigger impact on 27-30 mm age-0 Lake Whitefish than Cisco during times of spatial overlap in late spring.

Miraj Kayastha[1], **Chenfu Huang**[1], Pengfei Xue[1, 2], Tao Liu[1], Daniel Titze[3] and Timothy Havens[1], [1]Michigan Technological University, [2]Argonne National Laboratory, [3]Great Lakes Environmental Research Laboratory. **Using Deep Learning to Reconstruct 42 Years of Great Lakes Surface Temperature.**

Accurate estimates for the lake surface temperature (LST) of the Great Lakes are critical to understanding the regional climate and while dedicated lake models of various complexity have been used to simulate LST, they often exhibit biases or come with significant computational costs. Moreover, existing historical LST datasets either have limited temporal coverage (<30 years) or offer a coarser spatial resolution (0.25° × 0.25°). Hence, in this research, we utilized a Long Short-Term Memory (LSTM)-based deep learning model to reconstruct the daily Great Lakes LST for an unparalleled 42-year period (1979-2020). This new LST dataset represents the Great Lakes using ~33,000 unstructured grid points at an approximate spatial resolution of 1 km. The LSTM was trained with seven meteorological variables from reanalysis data as feature variables and the LST from a historical satellite-derived dataset as the target variable. The LSTM was able to capture the spatial heterogeneity of LST in the Great Lakes well and exhibited high correlation (≥0.92) and low bias (limited to ±1.5 °C) for the temporal evolution of LST during the training (1995-2020) and testing (1979-1994) periods. Our new LST dataset complements the existing LST datasets, offering the Great Lakes scientific community an innovative and reliable alternate source of LST for overlake surface boundary conditions in regional climate models, lake model validations, and long-term spatiotemporal LST analysis.

Herbert Nakiyende[1], Anthony Basooma[1], **Joyce Ikwaput Nyeko**[2], William Okello[1], Richard Rugadya[3], Christian Albrecht[4], Theodore Lawrence[5], Maarten Van Steenberge[4], Stephanie Smith[5], Nshombo Muderhwa[6], Joseph Matunguru[7], Mbalassa Mulongaibalu[8] and Zeph Migeni Ajode[5], [1]National Fisheries Resources Research Institute (NaFIRRI), [2]Lakes Edward Albert Fisheries and Aquaculture Organisation (LEAFAO), [3]Directorate of Fisheries Resources, Ministry of Agriculture Animal Industry and Fisheries, [4]Department of Animal Ecology and Systematics, Systematics and Biodiversity Lab Aquatic Biodiversity and Biogeography Group, Justus Liebig University Giessen, [5]African Center for Aquatic Research and Education, [6]Centre de Recherche en Hydrobiologie, [7]Doctoral School of the University of Burundi, Faculty of Science, Department of Integrated Management of Fisheries and Wetlands Ecosystems , [8]Faculty of Sciences and Applied Sciences, Official University of Bukavu. **Limitations for informed decision making and better management of the transboundary Lake Albert resources.**

Lake Albert, located in the western arm of the East African Rift Valley and shared between Uganda and the Democratic Republic of Congo supports a rich diversity of aquatic fauna and flora. The lake's biodiversity is threatened by anthropogenic stressors such as excessive fishing effort, destruction of shoreline vegetation, and increasing water pollution. Estimated 73% of the riparian communities are dependent on fishing as the major economic activity supporting their livelihoods. Over 50% of the people involved in the fisheries are women engaged in processing and marketing. However, limited data and information exists on the lake's fisheries and biodiversity to inform sustainable development and management decisions. Examination of past and current research and management efforts on Lake Albert reveal the most critical gaps that need to be addressed to restore the ecosystem health of Lake Albert. Previous research interventions were limited in scope, focused on catch-effort assessment, skewed to the Uganda portion of the lake, with minimal attention to the

lake's diverse biodiversity and ecosystem as a whole and potential impacts of the oil and gas exploration. We propose long-term ecosystem-based research processes in addition to socio-economic studies to obtain comprehensive information that will positively inform good management policies for healthy and sustainable resources in the lake in transboundary adaptive management.

Edina Illyes[1], Christine M. Boston[2], Nicole A. Turner[2] and Nicholas E. Mandrak[1, 3], [1]Department of Physical and Environmental Sciences, University of Toronto Scarborough, [2]Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries and Oceans Canada, [3]Department of Biological Sciences, University of Toronto Scarborough. **Pets going wild? Probability of Goldfish (*Carassius auratus*) dispersal from urban ponds.**

Habitat connectivity through the landscape is essential for conserving biodiversity. However, in the context of non-native species, the concept of connectivity constitutes a challenge as it can facilitate their dispersal and introduction to previously unaffected areas. With the increase of urbanization, this conundrum is further complicated. Urban development is often associated with the creation of stormwater management ponds (SWMPs) that are regularly connected and drain to natural waterbodies and have been found to be frequently inhabited by non-native species, such as Goldfish (*Carassius auratus*). By applying circuit theory and including land cover and watercourse types, elevation, and the location of culverts as potential barriers to fish movement across the landscape, we evaluated the potential of SWMPs facilitating the spread of non-native fish species to natural systems throughout Hamilton, Ontario. SWMPs that are connected to natural watercourses, such as streams, surrounded by naturalised land cover, and/or in close proximity to natural waterbodies, such as lakes, are characterized by greater relative conductivity and are inhabited by native fish species, which are hypothesized to have colonized them through natural dispersal. Conversely, such ponds may also be inhabited by introduced species which may represent risks to connected natural waterbodies and potential source populations of non-native taxa. Consequently, our work has implications for aquatic invasive species management, particularly in the light of continuing urbanization and SWMPs spreading across the landscape.

Dana Infante, Department of Fisheries and Wildlife, Michigan State University. **It's about the people: A key to fisheries management.**

In 2005, a conversation with Dr. William (Bill) Taylor set the course of my career as a fisheries ecologist. He presented me with an exceptional opportunity, mentored me as a new professional, and, over the last 15 years, expanded my view of what it means to manage and conserve fisheries along with key strategies for doing so. "It's about the people," Bill would say frequently, and experience has shown me the truth in that saying for effective fisheries management and conservation. Related, I've also seen many of the successful outcomes of Bill's strategic efforts to provide people with opportunities and mentorship and to forge new collaborations. In this presentation, I describe some of Bill's achievements in our field that stem from his relationships including his efforts to initiate the Janice Lee Fenske Excellence in Fisheries Management Fellowship, promote Fly Gals, diversify faculty in the Department of Fisheries and Wildlife, and support the Partnership for Ecosystem Research and Management with the Michigan Department of Natural Resources and the Great Lakes Fishery Commission. While these are just a few examples of Bill's many achievements, they clearly show how his care and support for people have made a difference in our field.

Alain Isabwe[1], Craig Stow[2] and Casey Godwin[1], [1]Cooperative Institute for Great Lakes Research, [2]NOAA-Great Lakes Environmental Research Laboratory. **Triggers of chlorophyll-a phenology in the western Lake Erie basin.**

Annual recurrence of harmful algal blooms (HABs) has plagued the western Lake Erie (WLE) basin for years. Synergic effects of temperature, nutrients, lake hydrology, and climatic factors contribute to this syndrome. Despite extensive studies on factors underlying HABs development in WLE and elsewhere, we lack an order of causal factors controlling primarily the growth and decay of chlorophyll-*a* as a proxy for HABs. Here an ensemble decision tree model, implemented in the Bayesian additive regression tree (BART), was used to evaluate the universality and the lack thereof of the relative importance of controlling factors for chlorophyll-*a* phenology. Seven candidate causal factors were evaluated using a long-term dataset of water quality parameters collected from 2012 to 2021 in WLE. During the chlorophyll-*a* growth period (R^2 = 0.83), total phosphorus, ammonia, and temperature had the highest variable importance. During the decay period (R^2 = 0.82), beam attenuation, total phosphorus, and ammonia appeared to exert the highest variable importance. This study provides insights into the internal and external factors for HABs development in WLE.

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Corbin Jacobs and Jillian Shawkence, Bkejwanong Eco-Keepers, NinDaWaabJig Walpole Island Heritage Centre. **Youth leadership in the Lakes with Bkejwanong Eco-Keepers from Walpole Island First Nation.**

This session will feature Indigenous Youth leaders from Bkejwanong Eco-Keepers from Walpole Island First Nation located on the shores of Lake St. Clair in the Laurentian Great Lakes Basin. They will describe the program, its' offerings and reflect on the shared experiences of Indigenous youth engaged in revitalizing their relationships with Mother Earth through cultural and environmental programming through teachings offered from Elders, community members, researchers and practitioners. This is a joint presentation.

Aisha Javed[1], Carlos Alberto Arnillas[1], Alex Neumann[1], Agnes Richards[2], Shan Mugalingam[3] and George Arhonditsis[1], [1]University of Toronto, [2]Environment and Climate Change Canada, [3]Lower Trent Conservation. **Evaluating the effectiveness of best management practices in mitigating phosphorus export from the Napanee River and Wilton Creek agricultural watersheds.**

Loads and circulation patterns of the Napanee River and Wilton Creek shapes the local biogeochemical processes, thereby modulating the severity of eutrophication in the picturesque Bay of Quinte (BoQ) receiving waterbody. In attempt to assist in guiding the long-term phosphorus management strategy in the BoQ and other similar agriculturally dominated areas, the objective of our research has been to apply Soil and Water Assessment Tool (SWAT) and evaluate the effectiveness of popular Best Management Practices (BMPs) in the case study watersheds. Our analysis shows that while the implementation of rotations and cover crops results in the greatest reduction in particulate phosphorus export (>30%), the implementation of vegetative filter strips result in the most reduction (>15%) for the soluble form of phosphorus. Nonetheless, our BMP assessment suggests that the greatest reduction for both low and high flow conditions and for both soluble reactive and particulate phosphorus occur when the BMPs scenarios are combined. Future projections suggest that the effectiveness of these combination of BMPs decreases relative to the

assessed present period, thereby highlighting the need for an adaptive modelling framework that can be used to assess alternative BMP scenarios in light of more current state of knowledge.

Songhao Ji[1, 2], Yanglin Li[1], Juan Tao[3] and Hugh J MacIsaac[1, 2], [1]School of Ecology and Environmental Sciences, Yunnan University, Kunming, China, [2]Great Lakes Institute for Environmental Research, University of Windsor, Canada, [3]Institute of International Rivers and Ecosecurity, Yunnan University, Kunming, China. **Trait-based functional ecology of successful fish invasions in 15 lakes in SW China.**

Determinants of successful invasion in aquatic ecosystems are often uncertain. Here we utilize trait-based characteristics to assess functional groups of native fishes present in 15 Plateau Lakes in SW China prior to 1969 (early). We contrast these functional groups against those present during the 1970-1980 (mid) and 2000-2010 (modern) periods when the lakes suffered from varying degrees of fish invasions. Fish species invasions per lake between early- and mid- periods were positively correlated with both total native fish diversity (r=0.60) and with diversity of individual functional groups (r=0.49), consistent with the 'rich get richer' hypothesis. Similarly, between the mid- and modern periods, the number of invasions per lake by new non-native species was positively correlated (r=0.66) with total fish diversity (native and pre-existing non-native species). However, new species invasions were unrelated to species diversity in functional group (r=0.18). Most invasions occurred between the early and mid- periods, whereas native species extinctions were most common between mid- and modern periods. Invasions mainly occurred into existing functional groups with extant native species, though in a number of cases new functional groups were formed by colonizing, non-native species or native species were replaced by non-native species.

Sabrina Jivani[1], Dillon Vyn[1], Pradeep Goel[2], Shagun Chaudhary[1], Imtiaz Shah[3] and Clare E. Robinson[1], [1]Western University, London ON, Canada, [2]Ministry of the Environment, Conservation and Parks, ON Canada, [3]Upper Thames River Conservation Authority, ON Canada. **Monitoring and Modelling Phosphorus Exports from a Cold Climate Urban Subwatershed.**

The need to quantify and control non-point source P exports from urban areas is becoming increasingly well recognized. Nevertheless, these exports including the relative contributions from different urban land use types, impact of rainfall characteristics, and seasonality are not well understood. Furthermore, despite increasing implementation of low impact development (LID) practices to reduce stormwater volumes and improve water quality, their integrated effect on reducing P exports at the subwatershed scale in cold climates remains unclear. The objective of this study is to evaluate P exports from a cold climate urban subwatershed, including the effectiveness of existing stormwater management controls, seasonality and contributions from different urban land uses. This objective was addressed by event-based monitoring over a 19-month period and the development and application of a hydrologic and water quality (SWMM) model. The study area was a 5.8 km^2 mixed land use urban subwatershed located in London, Ontario in the Lake Erie Basin. Monitoring was conducted across multiple stormwater control measures and at two subwatershed outlet points. Water quantity and quality data was used to calibrate and validate SWMM event-based and continuous models. The model was applied as a tool for evaluating monthly total suspended solids (TSS), total phosphorus (TP) and soluble reactive phosphorus (SRP) subwatershed exports and explore the influence of future land management scenarios.

Laura Johnson, Nathan Manning and Judy Dezse, Heidelberg University. **Drivers of annual suspended sediment and nutrient yields in tributaries to Lake Erie.**

There is substantial variability in suspended sediment and nutrient yields across Lake Erie tributaries. It is well known that agricultural and urban land uses lead to increased watershed sediment and nutrient yields, especially in the absence of proper management practices. Yet attributes such as watershed soil types and slope can also affect yields. We examined the influence of watershed land use, hydrology, soil type, and slope on annual nutrient and sediment yields from tributaries to Lake Erie monitored as part of the Heidelberg Tributary Loading Program. A minimum of one sample and, during storm runoff, up to three samples a day are analyzed for all major nutrients and suspended sediments. The 5-year average annual yields across these watersheds exhibited distinct geographic patterns from west to east, with high suspended sediment but lower nutrient yields from the eastern most tributaries (Cuyahoga, Old Woman Creek, Huron) and the lowest sediment along with lower nutrient yields from the western most tributaries (Raisin, Tiffin, Lost). The Maumee, Portage, Sandusky, along with select subwatersheds tended to have intermediate sediment yields with high nutrient yields. Altogether, the % cultivated crops and poorly drained soil in the watershed increased nutrient yields whereas a higher % slope and lower % pasture increased sediment yields. These patterns highlighted unique regional differences that can help guide management decisions for these watersheds that ultimately would improve the health of Lake Erie.

Lucinda Johnson[1], Li Wang[2], Matthew Child[2], Michael Donahue[3], John Bratton[4], Tad Slawecki[4] and Michael Twiss[5], [1]Natural Resources Research Institute, University of Minnesota-Duluth, [2]Great Lakes Regional Office, International Joint Commission, [3]Water Resources and Environmental Services, AECOM Technical Services, [4]Limnotech, [5]Faculty of Science, Algoma University.
Formalizing an Early Warning System for the Great Lakes for Future Protection.

The International Joint Commission (CA/US) has a defined role in the Great Lakes Water Quality Agreement to identify emerging issues and recommend strategies and approaches for preventing and resolving the complex challenges facing the Great Lakes (Articles 7 and 8). Yet no formal process exists to identify and act on threatening issues. To address this need, the IJC undertook a two-phase project to develop an organizational approach and decision framework for a Great Lakes Early Warning System (GLEWS) to define the process by which different risks posed by existing and potential threats and stressors are evaluated and subsequently communicated and mitigated. The primary audience for GLEWS is the responsible federal governments, yet other governments, NGOs, and public interest groups are stakeholders and rights holders. Two workgroups were assembled to guide the development of this framework: the first recommended that the IJC create a GLEWS Committee to serve the Great Lakes Water Quality Board (Article 8), which in turn alerts the Commission. The second workgroup proposed a process by which known, suspected, and unknown threats could be monitored and tracked; existing monitoring data, predictive models, and analytical tools could be identified; and a library of threats could be compiled to be revisited for further action if not deemed a priority. A pilot project to test the framework was recommended and a proposal is being evaluated.

Peter Johnson, Great Lake St. Lawrence Governors & Premiers. **Collaboration during times of uncertain water budgets.**

At the intersection of Science, Policy, and Management, the Great Lakes-St. Lawrence River Basin Sustainable Water Resources Agreement (Agreement) and corresponding Compact call for providing leadership in developing science that would improve management of the Great Lakes-St. Lawrence River system. As stated in the Great Lakes-St. Lawrence Regional Body and Compact

Council Science Strategy "…the integration of information about the impacts of climate change on the Great Lakes Basin water balance is a key challenge." The Great Lakes St. Lawrence Governors & Premiers serves as the Secretariat to the Great Lakes St. Lawrence River Water Resources Regional Body and Compact Council. In that role, Peter Johnson has served as the primary point person in development and implementation of the Regional Body and Compact Council's Science Strategy, including the coordination of the creation of the Cumulative Impact Assessment as well as any policy responses that may arise from climate change—including what may occur when there impacts to the water budget. This presentation will focus on setting the stage on how the States and Provinces cooperatively manage the waters of the Great Lakes St. Lawrence River System, and how the systems and processes contained in the Compact and Agreement will incorporate science into policy responses and collective actions.

Maggie Jones[1], Michael Wagner[1], Roger Bergstedt[2], Xochitl Gonzalez[1] and Erick Larson[2], [1]Michigan State University, [2]USGS Hammond Bay Biological Station. **Casting toward shore: vertical movements reveal timing and duration of shoreward migration in sea lamprey.**

Sea lamprey (*Petromyzon marinus*) is a parasitic invasive species that kill fishes of economic and cultural importance to peoples of the Great Lakes. After parasitic feeding concludes, sea lampreys migrate toward shore in search of a spawning river. During this phase they exhibit a characteristic pattern of vertical casting through the water column. Here, we examined the onset and expression of this behavioral pattern in actively migrating sea lamprey using pressure and temperature data obtained from surgically implanted data storage tags (DST). From 2003-2005, 240 parasitic lampreys were implanted with DSTs that recorded every 7.5 min, and then released into Lake Huron. Five were recaptured in rivers 6-9 months later. These data represent the first long-term information on sea lamprey migratory behavior in the lakes. Our goals were to determine when active migration begins, to describe behavioral patterns related to diel timing, depth, and frequency of casting, and to examine differences across individuals. We will discuss the implications of our findings for understanding the sea lamprey's navigational strategy during the spawning migration and the spatial distribution of spawning throughout the basin. Because control of sea lamprey is achieved by killing larvae in spawning streams, an improved understanding of how they navigate to and select spawning streams will aid in anticipating how these distributions may change in the future in response to shifting host distributions and climate change.

Zach D. Jones[1], Aaron T. Fisk[1], Brett Studden[2], Silviya V. Ivanova[1], Trevor Middel[3], Mark Ridgeway[3] and Bailey McMeans[2], [1]University of Windsor, [2]University of Toronto Mississauga, [3]Harkness Laboratory of Fisheries Research, OMNRF. **Effects of winter phenology on the activity and behaviour of an invasive warmwater predator fish.**

Shortening winters caused by climate change is thought to slowly relieve the barrier for invasive warmwater fish species like smallmouth bass (*Micropterus Dolomieu*) to expand northwards in the Laurentian Great Lakes basin. To understand how adult smallmouth bass performance may be influenced by shortening winters in northern regions, it is essential to understand how their overwintering behaviour responds to thermal cues associated with winter phenology. We hypothesized that smallmouth bass remain active for as long as there is thermal stratification, as a function of their foraging efforts to prepare and recover from winter stress. To address this, we used fine-scale position data from acoustic telemetry to quantify movement and behaviour in relationship to winter phenology across two years in a lake within Algonquin Park. Preliminary results suggest behavioural plasticity in relation to interannual variation of fall cooling. Smaller lakes act as a mesocosm to study the movement ecology of fish populations, and this research will improve the

understanding of how climate change influences the performance of smallmouth bass and alter ecosystem structure within the northern Laurentian Great Lakes region.

Aaron Jubar[1], Lexi Sumner[2], Lauren Freitas[1] and Matthew Lipps[1], [1]U.S. Fish and Wildlife Service, [2]Department of Fisheries and Oceans, Canada. **Spatial distribution of invasive larval sea lamprey (Petromyzon marinus) in the St. Clair River.**

The invasive sea lamprey (*Petromyzon marinus*) is a parasitic species which spends part of its life in a larval stage burrowed into silty substrate in streams, rivers, and associated lentic areas throughout the Great Lakes basin. The St. Clair River and channels contain abundant spawning and larval habitat available to sea lamprey. In 2011, Sea Lamprey Control Program agents from Canada and the US conducted RoxAnn habitat mapping in the St. Clair River and determined that 1,351 hectares was suitable larval habitat. Since 2012, control agents have surveyed a mix of fixed index locations and random sites within the river and channels. Due to the depth of the larval habitat in the river, surveys require the use of 3.2% granular Bayluscide (a form of lampricide) applied to 500 m^2 plots. The Bayluscide settles to the river bottom where it activates and causes larval lamprey to exit their burrows and forces some individuals to surface where they can be collected with scap nets. Sea lamprey larvae have been found throughout the St. Clair River, all three lower river channels, and in parts of the delta in Lake St. Clair. The highest densities of sea lamprey larvae are found in the upper river, but their distribution can shift annually. Continued monitoring of the larval sea lamprey population in the St. Clair River is needed to determine if future treatment is necessary.

Jennifer Jury[1], Natalie Gervasi[2], Yin Fan[2], Jamie Ferguson[2] and Deanna Fielder[1], [1]U.S. Army Corps of Engineers, Detroit District, [2]Environment and Climate Change Canada, Great Lakes - St. Lawrence Regulation Office. **Coordinating Bi-National Hydroclimate Data and Metadata.**

The Great Lakes - St. Lawrence River system uses various water data for effective water management. Datasets include water levels, net basin supplies (NBS), flow through the connecting channels, and flow diversions into and out of the system. Having bi-nationally coordinated data is essential to running regulation and routing models for effective decision making by the International Joint Commission's Great Lakes Boards. Metadata is useful to include within data files for explanation, history, and coordination. In this presentation, metadata for Great Lakes water levels will be a focus as it is the most widely requested dataset from stakeholders and is critical for water management. Great Lakes water levels have been calculated using a network of water level gauges in both the U.S. and Canada since the period of record began in 1918. For proper water level gauge measurements, gauge pairing logic and its history are important to record, coordinate, and capture as metadata. Clear and comprehensive metadata for Great Lakes water levels are presented in standardized files according to the Climate and Forecasting (CF) Conventions. These datasets are currently being compiled and coordinated and will be made available to the public under the auspices of the Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data.

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Alexander Kain[1], Mark Rowe[2], Casey Godwin[1], Reagan Errera[2] and Ashley Burtner[2], [1]Cooperative Institute for Great Lakes Research, [2]Great Lakes Environmental Research Laboratory. **Estimation of *Microcystis* Buoyancy by Calibrating a Numerical Model to In-Situ Observations.**

Cyanobacterial harmful algal blooms dominated by *Microcystis* sp. have occurred each summer in western Lake Erie and Saginaw Bay of Lake Huron since the early 2000s. There are

multiple methodologies providing evidence that the buoyancy of *Microcystis* differs between the two lakes, which has important implications for estimating bloom severity from remote sensing and predicting the effects of wind mixing on algal colonies. HAB forecast and management models require specification of the buoyant velocity, which is the floating/sinking terminal velocity. We estimated the buoyant velocity by calibrating a one-dimensional vertical Lagrangian Particle Dispersion model to vertical profiles of cyanobacteria abundance measured by Fluoroprobe in Western Lake Erie and Saginaw Bay. The model simulated vertical profiles resulting from mixing with buoyant colonies, forced by turbulent diffusivity output from a hydrodynamic model. We found that blooms were positively buoyant in Western Lake Erie and negatively buoyant in Saginaw Bay, consistent with previous studies using other methods. In addition, we found that satellite imagery showed decreased surface cyanobacteria concentration associated with higher winds in Western Lake Erie, and the opposite in Saginaw Bay, consistent with buoyancy estimates. We regressed buoyant velocities on environmental variables and found potential association of buoyancy with nutrient status.

Georgina Kaltenecker[1], Carl Mitchell[1], Todd Howell[2] and George Arhonditsis[1], [1]University of Toronto - Scarborough, [2]Ministry of Environment, Conservation and Parks. **A Comprehensive Assessment of Concentration-Discharge Relationships across spatial and temporal scales in Southern Ontario.**

Tributaries support many important ecosystem functions and are facing stressors from anthropogenic activities and climate change. Concentration-discharge (C-Q) relationships provide meaningful and insightful information on water quality responses to streamflow, climate, and watershed processes. We provide a comprehensive assessment of C-Q relationships for watersheds across Southern Ontario for a range of water quality constituents across both spatial and temporal scales. On a broad scale using long-term datasets, we illustrate how land use/cover and climate influence observed C-Q relationships and changes in slope over time. Results include linkages between land use/cover and enriching behaviour and shifts in C-Q slope over time. On a finer spatial and temporal scale using high-frequency data we examine event-scale C-Q relationships in the context of event characteristics and examine the importance of precipitation magnitude, duration, and antecedent conditions on observed event C-Q behaviours. We conclude with a comparison of event-scale (high-frequency data) vs. long-term (monthly data) C-Q relationships. The findings from this work provide insightful information on the variability and trends in stream water quality in the context of changing land uses/cover and climate change, contributing to effective watershed management.

Alexander Karatayev, Great Lakes Center, SUNY Buffalo State. ***Dreissena*** **in Great Lakes: Population dynamics and population assessment using conventional method and videography.**

Strong ecological and economic impacts of zebra and quagga mussels (*Dreissena polymorpha* and *D. rostriformis bugensis*) on the invaded waterbodies require timely and reliable estimates of their population densities. However, samples collected with conventional methods takes years for processing. In this study we analyzed video recorded using a Benthic Imaging System to assess quagga mussels distribution and density in near-real time (during a typical two-week cruise aboard EPA research vessel *Lake Guardian*) in Lake Michigan in 2021 and in Lake Huron in 2022 and compared that data with the Ponar grab samples collected at the same sites. We found that, videography could be a reliable and useful addition for dreissenid monitoring, especially on hard substrates where bottom grabs are not efficient. Analysis of dreissenid dynamics since the late 1990s

revealed a strong increase in mussel density in the shallowest polymictic zones of both lakes, suggesting local boom and bust dynamics. In the deepest zone of Lake Michigan there was a further increase in quagga mussel density coincided with the 9-fold decline in *Diporeia* density. Declines in *Diporeia* were also recorded in the main basin and in Georgian Bay of Lake Huron.

Yordanos Getachew Kasahun, Tadesse Fetahi Hailu, Demeke Kifle Tsega and Mathewos Hailu, Addis Ababa University. **Assessment of water quality, phytoplankton, zooplankton and trophic interaction of Lake Tinshu Abaya.**

Anthropogenic pressures increasingly threaten freshwater ecosystems, compromising water quality and ecosystem stability. This study focuses on Lake Tinshu Abaya, assessing its limnological and biological aspects, including physico-chemical parameters, trophic structures, and energy flow. Sampling was conducted monthly at three sites from May to August 2022, following standardized methods. Ecotrophic modelling with Ecopath and Ecosim software (version 6.6) was employed to analyze trophic interactions, energy flows, and ecosystem properties. Results revealed that the lake has relatively high temperatures and well-oxygenated conditions. However, the lake exhibited turbid water, a shallow Secchi depth (0.082 m), and elevated nutrient and alkalinity levels. Principal component analysis highlighted the substantial contribution of TDS, temperature, nitrate, nitrite, ammonia, and turbidity to water quality. Phytoplankton analysis identified 32 taxa across six divisions, dominated by cyanobacteria and Bacillariophyta. Phytoplankton biomass (Chl-a) ranged from 9.12 to 20.08 µg L-1. Zooplankton analysis identified 25 typical tropical species, with Rotifera (60%), Copepoda (8%), and Cladocera (32%) as major contributors. Ecopath modelling identified seven functional groups with trophic levels ranging from 1.00 for primary producers to 3.56 for predator birds. Ecosystem maturity indices, total primary production/total respiration, and Connectance index were 1.19 and 0.555, respectively, indicating Lake Tinshu Abaya's developmental stage. This study presents the inaugural trophic model of Lake Tinshu Abaya, providing insights into its trophic interactions and ecosystem functioning.

Donna Kashian[1], Mohamed Dabaja[1], Ahmad Ezzeddine[1], Stephanie Hartwell[1], Nadia Harduar[2], Elena Past[1], Lee Rodney[2], Halima Salah[1], Anneke Smit[2] and Edwin Tam[2], [1]Wayne State University, [2]University of Windsor. **Centering Sustainability in the Great Lakes through the United Nations Regional Center of Expertise.**

Sustainable Great Lake ecosystems require overcoming detrimental ecological, social, and economic challenges. Large lakes can span multiple jurisdictional boundaries, necessitating a multifaceted and multi-beneficial approach to advance sustainability. Large collaborative organizations, like universities and agency partnerships, can facilitate this approach, center sustainability regionally, and provide a model framework for sustainability practices basin-wide. Such is a goal of the newly designated bi-national United Nations Regional Centre of Expertise (UN-RCE) on Education for Sustainable Development in the Detroit-Windsor region hosted by Wayne State University and the University of Windsor. This bi-national center will serve as a *boundary spanner*, providing a bridge between educational institutions and community partners including agencies, industry, and non-profits to enable knowledge exchange and share values around sustainability. Great Lakes sustainability efforts will benefit from the UN RCE's focus on three Sustainable Development Goals (SDG): Clean Water and Sanitation (SDG 6), Quality Education (SDG 4) and Life Below Water (SDG 14). Our goal is to identify networks and resources to address these SDGs, identify challenges that sustainability programs often face, and chart pathways forward. Initial challenges identified by community partners include siloed efforts/disciplines, public skepticism, ineffective communication, ineffective participation, and incorporation of sustainability

outcomes in plans. Contributing factors for success include diverse networks and established histories of interdisciplinary. Sustainable Great Lake ecosystems will necessitate a transdisciplinary, collaborative, multisectoral, approach the UN-RCE can foster.

Padma Kasthurirangan, Buffalo Renewables Inc. **Wind and Solar along the Great Lakes.**

Home to the AC vs DC wars, the iconic Niagara Falls is not new to renewable energy generation. In addition to the obvious hydro power, the winds coming off the lakes and the large open areas also have an unlimited supply of wind and solar power. The lands around the great lakes have tapped this energy in unique ways. This talk will provide a comparative analysis of the energy resource, opportunities and hurdles with wind and solar deployment in the US side of the Great Lakes region.

Shaelynn Kaufman[1], Sydney Bufkin[1], Jacob Berkowitz[1], Derek Schlea[2], Chad Toussant[3] and Jacob Piazza[1], [1]Army Corps of Engineers, Engineer Research and Development Center, [2]LimnoTech, [3]US Geological Survey. **Closer to the source: Improving Lake Erie water quality by restoring watershed wetlands.**

Wetlands inherently filter and sequester nutrients from surface waters, presenting a natural solution for mitigating nutrient loading in water bodies like Lake Erie, where excessive phosphorus (P) leads to HABs. Wetland soils can effectively store P, but face limitations in P retention capacity, especially in agricultural areas where elevated legacy P concentrations may occur. This study employed mesocosms and intensive field study to adaptively manage an 18-ha constructed wetland in the Maumee River Basin, aimed at reducing P loading to Lake Erie. Ongoing mesocosm experiments aim to enhance field operations through examination of variations in the hydrologic regime, vegetation, and amendment management, whilst simultaneously, semiannual soil sampling conducted across the field-site is intended to elucidate the impact of management practices. Preliminary results of mesocosm and constructed wetland studies consistently exhibit a lower dissolved P mass in the effluent compared to the influent water, with a reduction ranging from 55-80% per hydrologic event. Soil P retention in the wetland varies with location, depth, and hydropattern, with up to 35% greater accumulation in areas subject to prolonged water inundation and greater vegetative biomass. Current efforts concentrate on deploying scaled P-sequestering technologies in strategically vital locations to extend nutrient reduction lifespans and optimize P sequestration. In summary, mesocosm scale R&D aims to provide operational guidance to meet regional water quality goals and maximize the benefits of restored & constructed wetlands for generations.

Manpreet Kaur[1], Ramesh Rudra[1], Prasad Daggupati[1], Pradeep Goel[2] and Pranesh Paul[1], [1]University of Guelph, [2]Ministry of the Environment, Conservation and Parks. **Frequency of threshold events affecting non-point source pollution in agricultural watersheds in Southern Ontario, Canada.**

In the era of escalating global emphasis on sustainable agricultural practices, it is imperative to unravel the complexities of hydrological processes contributing to non-point source (NPS) pollution in agricultural watersheds. This study addresses a knowledge gap in understanding the relationships between land use, hydrological processes, and NPS pollution to the Lower Great Lakes. The investigation of precipitation events that are responsible for surface runoff has been identified as the primary means for transporting sediments and phosphorus loads from agricultural fields to the stream. The study emphasizes threshold precipitation events, which cause significant sediment and phosphorus loads, and analyzes their frequency on an annual and seasonal basis. The

objective of this research is to understand the spatial and temporal variations in threshold events across diverse agricultural watersheds. By delving into both annual and seasonal events, the aim is to offer insights that are crucial for informed watershed management and conservation efforts in Southern Ontario, Canada. The study's findings have the potential to help understand the effects of Best Management Practices on rapid components of stream flow, sediment, and phosphorus loads.

Kat Kavanagh, Water Rangers. **Water Rangers' community science evolution: From data to action.**

Water Rangers is a not-for-profit social enterprise, founded by Kat Kavanagh in 2015 after winning AquaAction's first AquaHacking competition. This presentation provides a history of the organization, spotlighting how local concerns and demand for community science tools shaped the design of our teskits, data platform, and educational resources. Kat will tell the story of the evolution of Water Rangers' tools and water literacy efforts, from the first freshwater testkit for community scientists to the establishment of watershed-wide programs in Ontario, Saskatchewan, and beyond. We'll also discuss the transition of the Watershed Reports from WWF Canada to Water Rangers, and provide an update on the work that is underway on the third edition of the reports, which will be published in the fall of 2024 on the Water Rangers website. Canada's Watershed Reports, the first national-scale assessment of the state of freshwater in Canada, have a new steward: Water Rangers assumed responsibility for the Watershed Reports in June of 2023. AquaAction joined Water Rangers as the exclusive sponsor of the Watershed Reports, and is supporting the transition to the new home, as well as the creation of the 2024 report. Community science, water literacy, and moving from data to action are central to this presentation.

Miraj Kayastha[1], Pengfei Xue[1, 2], Chenfu Huang[1], Jiali Wang[2], Zhao Yang[3], William Pringle[2], Tirthankar Chakraborty[3], Yun Qian[3] and Robert Hetland[3], [1]Michigan Technological University, [2]Argonne National Laboratory, [3]Pacific Northwest National Laboratory. **How Could Lake-Effect Snow Storms Evolve in a Warming Future Climate?**

As cold, dry air passes over a warmer lake, it triggers lake-effect snow (LES) by increasing the moisture transfer from the lake to the atmosphere, leading to cloud formation and eventual precipitation. During November 17-20, 2022, a record-setting LES storm devastated Buffalo, New York, with nearly 7 feet of snow. Using a cloud-resolving 4 km scale, we investigated how such an LES storm might manifest in a warmer future climate by employing the Pseudo-Global Warming (PGW) method and a two-way coupled lake-atmosphere regional climate modeling system, which consists of a two-way coupled Weather Research and Forecasting (WRF) model and a Finite Volume Community Ocean Model (FVCOM)-based three-dimensional lake model. According to our findings, the total storm precipitation for such an event by the end of this century could increase by 14% under a high-emission scenario, with an increase in rainfall at the expense of snowfall. Under present-day climate, snowfall was the primary type of precipitation. However, under a warmer future climate, the distribution of precipitation might be nearly equal between snowfall and rainfall. Through two additional simulations in which either the lake or atmosphere is warmed individually to the warmer future conditions, we found that the warmer lakes primarily contributed to the increase in storm precipitation through increased evaporation, while the warmer atmosphere primarily influenced the form of storm precipitation during such an LES storm in the future.

Naomie Kayitesi[1], Alphonce Guzha C.[2], Marj Tonini[1] and Gregoire Mariethoz[1], [1]Institute of Earth Surface Dynamics, University of Lausanne, Lausanne, Switzerland, [2]International Union for Conservation of Nature (IUCN), East and Southern Africa Region. **Modeling Land Use Land Cover Change and hydrological processes in the African Great Lakes region: case study of the Lake Kivu catchment, Rwanda.**

The African Great Lakes Region (AGLR) has experienced substantial Land Use and Land Cover Change (LULCC) over the last decades, significantly impacting landscapes and ecosystems. Drivers of LULCC involve a complex interplay of political, economic, and socio-demographic factors. Focusing on Rwanda's Lake Kivu catchment, a critical ecosystem in the AGLR, this study explores historical and future LULC scenarios. The methodology involved supervised image classification, integrating spectral indices with topographic features to capture seasonal variations. Historical LULCC analysis revealed the first decade's (1990-2000) substantial forest loss (26.6% to 18.7%) and notable agricultural land increase (27.7% to 43%), attributed to conflicts in the region and population movements. Subsequent decades (2000-2010& 2010-2020) witnessed forest recovery (24.8% by 2020) and a balanced agricultural shift, reflecting Rwanda's environmental commitment. A multi-layer perceptron artificial neural network was employed to predict future LULC scenarios, considering natural and socio-economic explanatory variables with historical LULC transitions. The predicted future LULC for 2030 and 2050 indicate distinct trajectories influenced by factors like political will, demographic trends, and socio-economic developments. Integrating observed trends and predicted scenarios, along with climate data, the study employs a hydrological model to understand catchment hydrological components' impacts. Providing essential insights for policy and strategic planning, this research explores how hydrological processes are influenced by LULC and climate changes, aiming to harmonize ecological sustainability with socio-economic development in the Lake Kivu catchment and similar AGLR environments.

Mitch Kehne[1], Gordon Paterson[1], Jill A Olin[1], Trista J Vick-Majors[1] and Jim R Junker[2], [1]Department of Biological Sciences, Great Lakes Research Center, Michigan Technological University, Houghton, MI, [2]Department of Biological Sciences, University of North Texas, Denton, TX. **Assessing the Nutritional Quality and Fate of Saginaw Bay Dreissenid Mussel Veligers.**

The introduction and establishment of dreissenid mussels into the Laurentian Great Lakes in the 1980s has resulted in significant biological and ecological change in this system. Research on dreissenid mussel effects in the Great Lakes has primarily focused on the adult life stages, with less known about the larval veliger form. Veligers range in size from approximately 70 - 200 µm with abundances in Great Lakes waters reaching 10,000s ind/m^3 during peak spawning times. This size range and abundance suggest that dreissenid veligers could represent a potentially abundant food resource for predatory zooplankton, larval fish, and planktivorous fish species. However, little is currently known regarding the nutritional quality of veligers as a food resource or the extent to which veliger production is assimilated by higher trophic level consumers. This research proposes to investigate i) dreissenid veliger energy densities and fatty acid profiles as indicators of their nutritional quality and; ii) determine the fate of veliger carbon within zooplankton and bacterioplankton communities of Saginaw Bay, Lake Huron. Preliminary results of ^{14}C labeling experiments demonstrate uptake of veliger derived organic carbon by zooplankton and bacterioplankton. Fatty acid profiles demonstrate veligers to have lower concentrations of polyunsaturated compounds including EPA, DHA, and α-ALA relative to bulk zooplankton. These results provide baseline information regarding veliger nutritional quality and fate of veliger production within the lower trophic levels of Lake Huron.

Eli Kersh, LakeTech, Inc. **Empowering stakeholders with scalable solutions.**

While the world of real time water quality instrumentation and telemetry is experiencing a Renaissance, there are still major obstacles and barriers to entry for the processing and visualization of this data. Another major gap is a lack of tools that integrate diverse datasets and operational data with monitoring data to create more comprehensive solutions. LakeTech founder Eli Kersh will share his team's experience designing a platform that is meant to be intuitive enough for a novice citizen scientist yet sophisticated enough to meet the needs of professional managers and researchers.

James Kessler, NOAA Great Lakes Environmental Research Lab. **5 Decades of Great Lakes Ice Cover Data.**

Satellite based ice cover data has been routinely processed by the US National Ice Center and Canadian Ice Service since the 1970's. GLERL has worked with both agencies and has a long standing history of post-processing, analyzing and hosting this data for public access. Ice cover data serves many key stakeholders including the US and Canadian Coast Guard, as well as the commercial shipping and fishing industries. Throughout the years, the data has evolved from hand-drawn maps to digitized products at various resolutions. In 2019, GLERL rigorously standardized and published the entire dataset which spanned nearly 5 decades at the time. This standardized dataset is invaluable to the Great Lakes Science community and provides a basis for long-term trend assessment in ice cover which is a key climate indicator in the region.

Ali Kheiri Mazraeh[1], Joseph Atkinson[1], Zhenduo Zhu[1, 2] and Brian Weidel[3], [1]State University of New York at Buffalo, [2]Tsinghua University, [3]United States Geological Survey (USGS). **Wave effects on sediment transport along the Lake Ontario shoreline.**

Accurate prediction of sediment transport in the Great Lakes affects many physical and biological processes and is critical, for example, in understanding impacts on fish spawning and egg survival, as excessive sediment deposition can reduce incubation success by preventing essential nutrients and oxygen from reaching eggs. In this research, a coupled hydrodynamic and wave model is developed to simulate sediment transport at three locations along the Lake Ontario shoreline: Chaumont Bay, Sodus Bay, and an open lake nearshore area near Oak Orchard Creek. The hydrodynamic model Delft3D was coupled with a wave model (SWAN) to obtain sediment transport results, since waves can be a key driver of sediment mobility. The coupled model was used to calculate velocities and bed shear stresses, and simulate transport for both fine and coarse grained sediment at these three areas. Compared to hydrodynamic modeling alone, the incorporation of waves can significantly increase bed shear stress in some areas, although in a protected embayment waves have only a small impact. The model results provide new insights into the spatial and temporal patterns of sediment movement along the Lake Ontario shoreline, which has been understudied. This better understanding of sediment dynamics will inform efforts to monitor and manage these important but vulnerable fish spawning habitats in Lake Ontario and help development and testing of potential restoration scenarios.

Katarina Kieffer[1, 2] and Kris Patterson[1], [1]Partners for Clean Streams, [2]Bowling Green State University. **Community Water Action Toledo: a case study of the collaborative power of volunteer science.**

Volunteer science can be a powerful tool for data collection at large scale, but it faces the well-known challenges of credibility and continuity. In the northwest Ohio region, non-profits and community groups have initiated water monitoring programs, but individual programs are not

always sustained. In addition to lapses in coverage, differing protocols and goals make it challenging to compare or compile data for a "big picture" of water quality in the region. Working with the Lake Erie Volunteer Science Network (LEVSN), Partners for Clean Streams (PCS) has spearheaded a new collaborative, Community Water Action Toledo (CWAT), with the goal of increasing understanding of water quality in Lake Erie tributaries and driving improvement for water quality across Northwest Ohio. CWAT has successfully navigated the challenges of setting up a non-hierarchical structure with shared leadership between core partners, completing our first sampling season across three watersheds in 2023 and engaging a wide range of volunteers in citizen science. By implementing the Lake Erie Baseline Assessment Framework (LEBAF) standards, CWAT has integrated the existing strengths and goals of our established partner organizations with the scientifically rigorous monitoring protocol outlined in LEBAF, allowing our data to serve both local needs as well as to be integrated with the larger LEVSN network and basin-wide analyses. 2023 CWAT members included PCS, the Toledo Zoo, Metroparks Toledo, and Toledo Metropolitan Area Council of Governments.

E. Anders Kiledal[1], Gregory J. Dick[1, 2], Robert Hein[1], Vincent J Denef[3], Melissa B. Duhaime[3], Subba Rao Chaganti[2], Reagan M. Errera[4], Casey Godwin[2], Ryan J. Newton[5], Cody S. Sheik[6], Daniel D. Heath[7] and Henry A. Vanderploeg[4], [1]Department of Earth and Environmental Sciences, University of Michigan, [2]Cooperative Institute for Great Lakes Research, [3]Department of Ecology and Evolutionary Biology, University of Michigan, [4]NOAA Great Lakes Environmental Research Laboratory, [5]School of Freshwater Sciences, University of Wisconsin-Milwaukee, [6]Large Lakes Observatory, University of Minnesota-Duluth, [7]Great Lakes Institute for Environmental Research and Department of Integrative Biology, University of Windsor. **Advancing 'Omics in the Great Lakes with the Great Lakes Atlas of Multi-omics Research (GLAMR).**

To collect and standardize the ever-growing volume of 'omics data (DNA or RNA sequences, metabolomics, etc.) produced by Great Lakes researchers, we built the Great Lakes Atlas of Multi-omics Research (GLAMR), a publicly-accessible website and database. To populate GLAMR, we collected Great Lakes metagenomic, metatranscriptomic, and amplicon datasets-including many of our own-from public repositories while simultaneously collecting and standardizing all available sample metadata, including associated environmental measurements. The recently-launched GLAMR website, greatlakesomics.org, allows users to explore and query datasets processed through standardized bioinformatics pipelines, and provides links to the originating repositories. GLAMR currently houses nearly 2,500 samples and we expect this number to grow rapidly as researchers increasingly rely on 'omics methods. By bringing together diverse datasets spanning 15 years from across the Great Lakes, GLAMR provides researchers and other Great Lakes stakeholders a powerful but accessible tool for understanding this critical freshwater ecosystem. GLAMR will allow tracking of how policies affecting land and water management in the Great Lakes basin and beyond impact the biological systems within the Great Lakes, including threats such as harmful algal blooms and invasive species.

Dustin Kincaid, Matthew Diebel, Samantha Oliver and Luke Loken, U.S. Geological Survey. **Nitrogen and phosphorus flux ratios in major U.S. tributaries to the Laurentian Great Lakes.**

Efforts to reduce nutrient loading to the Great Lakes often focus on single nutrients. In addition to absolute nutrient concentrations, ecological dynamics in lakes are influenced by relative nutrient concentrations (stoichiometry) and forms (bioavailability: percentage dissolved inorganic nutrients). Particularly, nitrogen to phosphorus (N:P) ratios and the bioavailability of both nutrients

can influence algal bloom dynamics, making understanding trends in ratios and bioavailability relevant to the Great Lakes. We analyzed trends in 24 Great Lakes tributaries for N and P fluxes estimated with data from the Great Lakes Restoration Initiative monitoring network. Evaluation of 2011-2020 N and P flux bioavailability and ratios demonstrated that the bioavailability of annual N and P fluxes increased for 19 and 17 of 22 tributaries, respectively, with cross-site median increases of 7 and 29%. Median seasonal bioavailability of both nutrient fluxes increased, except spring for P, which decreased. For dissolved inorganic N:P ratios of annual fluxes, half of the tributaries had decreasing trends, with a median change of -8%. Conversely, most sites (16 of 24) had increasing trends for total N:P ratios of annual fluxes, with a median increase of 12%. Seasonally, median dissolved inorganic and total N:P flux ratios decreased in fall and winter and increased in spring and summer. Generally, trends in N and P flux composition reflect changes in N flux magnitudes and P flux bioavailability, with potential implications for Great Lakes ecology.

Katelyn King[1], Cory Brant[2] and Karen Alofs[1], [1]University of Michigan, [2]United States Geological Survey. **Modeling historical spawning habitat of cisco (*Coregonus artedi*) in Lake Erie to support coregonine restoration.**

Coregonine populations have generally declined over the past century throughout the Great Lakes, with some species now considered extirpated, and some considered extinct. The Council of Lake Committees endorsed a knowledge and science-based approach to restoring these culturally, ecologically, and economically important fishes known as the Coregonine Restoration Framework. As a part of the science planning component of this framework, we aim to compare historical and contemporary coregonine spawning distributions across the Great Lakes to identify suitable areas for stocking, habitat restoration, and the potential for habitat creation. Here, we present a case study examining historical habitat suitability for cisco (*Coregonus artedi*) in Lake Erie. Given that historical data on coregonine species can be patchy or relatively scarce and is commonly presence-only, we used Maxent for modeling and estimating habitat suitability. We used a novel historical coregonine database, called CORHIST, that was recently built by a team of scientists across agencies and has 96 cisco spawning records from the 1850s-1970. We combined these observations with habitat layers including estimated reef suitability, distance to wetlands, fetch, and novel historical substrate and historical ice duration data. Our model performed well, with an AUC of >0.8. We also determined if the historical model predicted the few cisco observations of the contemporary time period and compared our model to a model using only, the widely available, Goodyear spawning data.

Lauren Kinsman-Costello[1], Ricky Becker[2], Thomas Bridgeman[2], Kennedy Doro[2], Stephen Jacquemin[3], Laura Johnson[4], Ganming Liu[5], Kevin McCluney[5], Helen Michaels[5], W. Robert Midden[5], Silvia Newell[6], Christopher Winslow[7], Olivia Schloegel[1], Raissa Mendonca[1] and Janice Kerns[8], [1]Kent State University, [2]University of Toledo, [3]Wright State University, [4]Heidelberg University, [5]Bowling Green State University, [6]Michigan Sea Grant, [7]Ohio Sea Grant, [8]Ohio Department of Natural Resources. **Evaluating Nutrient Function Across Diverse Wetland Projects: The H2Ohio Wetland Monitoring Program, Ohio, USA.**

To assess the nutrient removal function of wetland projects being implemented as part of the H2Ohio Initiative, the Ohio Department of Natural Resources has established a monitoring program implemented by teams from six Ohio universities. The H2Ohio Wetland Monitoring Program (WMP) takes advantage of a unique opportunity to investigate nutrient cycling in diverse wetlands under a unified framework. We are developing tools for nutrient budgeting and indicators of wetland nutrient function using a tiered approach. Indices nutrient status and hydrology are measured in all monitored projects, while we collect more intensive data for comprehensive nutrient

budgeting in select "Focal Projects." This tiered approach balances evaluation of broad, state-wide restoration program trends and robust, mechanistic understanding to inform management. The H2Ohio WMP has now produced baseline data from monitoring surface water and soil nutrients, and basic hydrology in approximately 30 projects. A centralized data management system ensures data quality, long term storage, and accessibility in accordance with open science best practices. This talk will provide an overview of preliminary results that will be released in the WMP's Annual Report in 2024. Surface water nutrient concentrations, soil nutrient status, and early nutrient load reduction estimates reflect the heterogenous hydrologic regimes, landscape connectivity, and land use histories of the diverse wetland restoration projects. Coordinating and leveraged research projects expand the scope of this monitoring program to meet broader goals throughout the Great Lakes.

Tyler Harrow-Lyle[1], Krista Chomicki[2] and **Andrea Kirkwood**[3], [1]Environment and Climate Change Canada, [2]Toronto and Region Conservation Authority, [3]Ontario Tech University. **Modelling of discrete and continuous data reveals role of coastal wetlands in nearshore water quality of Lake Ontario.**

Coastal wetlands in the lower Laurentian Great Lakes are considered priority areas for restoration and protection due to historic human impacts that have caused wetland loss and degradation. Coastal wetlands are not only valued for their biodiversity and habitat provisioning for wildlife, but also their ecosystem services such as flood mitigation and nutrient retention. However, it is largely unknown if coastal wetlands in Lake Ontario effectively serve as net nutrient sinks, and whether this ecosystem service varies across wetlands as a function of their geomorphology and ecological condition. Using multi-year discrete wetland water quality data collected by the Toronto and Region Conservation Authority from 4 Lake Ontario coastal wetlands (Rouge, Frenchman's Bay, Duffin's, and Carruthers), and continuous data from a Fisheries and Oceans Canada buoy deployed in Lake Ontario over the same time-period, we developed explanatory models for wetland water quality dynamics and seiche-mediated phosphorus and *E. coli* loading to the Lake Ontario nearshore zone. Overall, our findings show that coastal wetlands can be significant sources of nutrients and *E. coli* to the nearshore zone due to sediment re-suspension and transport by seiches. Our findings provide support for restoration efforts that aim to improve the nutrient retention capacity of coastal wetlands, including mitigating the impacts of seiche inundation.

Lily Kisaka[1], Frank Masese[2] and Chrisphine Nyamweya[3], [1]Department of Agriculture and Veterinary Medicine, Kibabii University, Bungoma, Kenya, [2]Department of Fisheries and Aquatic Sciences, University of Eldoret, Eldoret, Kenya, [3]Kenya Marine and Fisheries Research Institute, Kisumu, Kenya,. **Community Science in Action: A Review of Practices in the Lake Victoria Basin.**

Despite the urgent need for sustainable management of resources in the Lake Victoria Basin (LVB), assessment and monitoring are hampered by incomplete data, inadequate financial resources and infrastructure to collect required information in conventional ways. Further, formal approaches are limited to the amount of data that can be gathered across large spatial and temporal scales. This prompted attempts by government and non-governmental agencies to rely on the inclusion of locals in providing or collecting data as part of community science. The concern about the quality notwithstanding, such data is important in providing a broader view of the ecological health to scientists. This paper will examine the potential of community science not only in overcoming data gaps but also in fostering collaboration between local communities and scientific endeavors. The research explores innovative approaches, including leveraging cell phones for efficient

communication of water gauge readings, actively engaging water resource user groups, employing geo-coding techniques to enhance data quality, fisheries data collection and developing citizen-based indices of ecological integrity. This talk will highlight the success stories, challenges, and future potential for applications of community science. Community science should be widely promoted for use in bridging data gaps to overcome a persistent barrier to the early warnings and investments needed to ensure short and long-term community resilience across the LVB.

Meghan Klasic, Katie Williams and Jesse Engebretson, U.S. EPA Great Lakes Toxicology and Ecology Division. **A review of social indicators of environmental restoration.**

Restoration is a hallmark of environmental work. Regulatory and voluntary programs across multiple levels of governance aim to improve or "restore" environments. In the United States, there are 25 federal statues implementing more than 134 restoration programs that equate to about $1B in spending each year. Environmental restoration can lead to immediate short-term pollution controls and promote long-term ecosystem health and climate benefit. Much research has been aimed at measuring pollution concentrations and toxicity before and after restoration projects. An often-overlooked area of environmental restoration is the social impact of these projects. Social indicators and measures can help quantify and qualify key benefits of restoration projects to individuals and communities. Using Sciome Workbench for Interactive computer-Facilitated Text-mining (SWIFT), a tool for searching, categorizing, and prioritizing bodies of literature, we systematically review articles and technical reports to identify social indicators of restoration projects in the United States. We then evaluate social indicator trends across geographies and topics (e.g., lake, wetland). This meta-analysis review provides a broad perspective on how to incorporate social indicators into restoration project monitoring and impact assessment, towards the goal of a more holistic social-ecological systems approach. The views expressed in this presentation are those of the authors and do not necessarily reflect the views or policies of the U.S. Environmental Protection Agency.

Greg Kleinheinz and Carmen Ebert, University of Wisconsin Oshkosh. **Regional Approach to Marine Debris Interception and Removal in Northern Lake Michigan.**

This presentation will explore the results of a regional approach to marine debris interception and removal in northern Lake Michigan. This project incorporated a suite of marine debris removal and interception technologies including passive collection and interception technology such as the Seabins and active collection and interception technologies such as the BeBot, Omni Cat marine debris boat, and Pixie Drones. While the passive technology was fixed, the active technology rotated through regional locations found to have marine debris present or were highly likely to have marine debris entering the Great Lakes. The mobility and rotation of technology on a daily basis allowed for larger geographic coverage which demonstrated a greater return on the investment of the technology. This was a critical outcome as the technology cost ranged from $130k for the OmniCat to $6k for the SeaBin. Each technology was effective in removing or intercepting debris, but also demonstrated limitations. In 2024, >12,000 pieces of marine debris, weighing close to 3,600 kg, were removed or intercepted from northern Lake Michigan. Preliminary results from demonstrated that over 90% of water samples from the areas where marine debris was collected also contained relatively easily detectable microplastics. The results from this study point to the need for more investigation of marine debris technology and the development of best practices for each technology to enhance further adoption and effective utilization throughout the Great Lakes.

Emily Klimczak and Dr. Christopher Pennuto, SUNY Buffalo State University. **Intensive trapping as a management action against red swamp crayfish.**

Red swamp crayfish (*Procambarus clarkii*) are invasive on every continent, except Antarctica. Attempted management techniques include trapping, male sterilization, and habitat modification. We initiated an intensive trapping program at a single invaded pond in western New York prior to attempting new controls (a future project). We set 1,543 baited traps over 55 nights from July to November 2023. 964 crayfish were trapped, of which 10 were native calico crayfish (*Faxonius immunis*), one was a native White River crayfish (*Procambarus acutus*), and the remaining 953 were red swamp crayfish. Catch per unit effort (CPUE) and total number caught both declined over time, though these trends may be related to the seasonal decline in water temperature and/or the increase in light penetration. Mean carapace length did not change over time. The sex ratio was evenly distributed at the beginning of the season but changed to male-dominated from late summer to early November, then switched to female-dominated in November. A late-season mark-recapture study was conducted using visible implant elastomer (VIE) tags and suggested that nearly 300 crayfish remain in the pond. These data suggest intensive trapping has an immediate impact on crayfish numbers and will assist us in determining if a proposed control method to enhance the competitiveness of similarly-niched species is effective.

Michael Zorn[1], Jessica Grow[2], Chris Houghton[1], Shelby Brunner[3], Joe Smith[3] and **Val Klump**[2], [1]University of Wisconsin-Green Bay, [2]University of Wisconsin-Milwaukee, [3]Great Lakes Observing System. **A GLOS LoRaWAN Sensor Network for tracking hypoxia and HABs in Green Bay, Lake Michigan.**

In an ongoing effort to demonstrate low cost means for collecting and transmitting relevant environmental data, and for demonstrating the potential for such systems to provide early warnings or diagnostics of potentially detrimental conditions, like hypoxia driven fish kills, cyanoHABs, flooding, etc. a total of 5 small LoRaWAN equipped buoys were deployed in 2023 in the mid/lower region of Green Bay. Sensor packages included Nexsens temperature strings, Yosemitech optical fluorescence sensors (Chl a & phycocyanin), and In-Situ RDO Blue DO/temp sensors. Most were solar powered and interfaced with Dragino RS485 controllers/transmitters. Deployment durations varied from 3 to 102 days, with transmission efficiencies ranging from 59% to 99% (Ave 74%) with some sites nearly out of range of LoRaWAN coverage. These platforms collectively transmitted 10,000+ data points to mega/field gateways in cooperation with the local cell provider, Cellcom, to Aexonis' Cemtore IoT mediation and management software platform, then onto the GLOS Seagull web site (https://seagull.glos.org/). Numerous bottom water hypoxia events across the network were captured, and excellent temporal and concentration coincidence was observed across these platforms and existing GLOS and NEW Water monitoring stations. Tentative plans for 2024 include incorporation of AUV missions for tracking across-grid hypoxia water masses, exploration of very small buoy/low-power sensor options not requiring solar support, and additions to the receiver array to expand spatial coverage to mid and northern sections of lower Green Bay.

Val Klump[1], **Gail Krantzberg**[2], Matthew Child[3] and Lizhu Wang[3], [1]University of Wisconsin - Milwaukee, [2]McMaster University, [3]International Joint Commission. **Towards the Development of a Decadal-Scale Great Lakes Science Plan.**

The International Joint Commission's Science Advisory Board (SAB) has completed a decadal-scale, multinational Great Lakes Science Strategy, and recently embarked on the development of a more detailed Science Plan. The high-level Strategy identifies an approach to improving our understanding of fundamental ecological processes in the lakes and their connecting

waters and our collective ability to forecast change and mitigate the impacts of stressors, thus improving management and policy decision-making. This presentation will introduce the content of the Strategy which will be discussed in greater detail through subsequent presentations. The presentation will also review the SAB's planned activities to develop a more detailed Science Plan that confirms science gaps and needs, identifies sustainable governance and management arrangements to ensure operational success, and estimates the needed level of investment.

Alexander Koeberle[1], Suresh Sethi[2], Lars Rudstam[1], Brad Hammers[3], Web Pearsall[3], Dan Mulhall[3], James McKenna, Jr.[4], Marc Chalupnicki[4], Meredith Bartron[5], Aaron Maloy[5], Chris Rees[5], Lauren Atkins[5] and Lewis McCaffrey[3], [1]Cornell University, [2]Brooklyn College and Cornell University, [3]New York State Department of Environmental Conservation, [4]USGS, Great Lakes Science Center, Tunison Laboratory of Aquatic Science, [5]US Fish and Wildlife Service, Northeast Fishery Center.
Acoustic telemetry and eDNA to evaluate cisco restoration in an inland lake.

Technological advances enable scientists to monitor aquatic species at greater spatial and temporal scales. Here, we applied acoustic telemetry and environmental DNA (eDNA) to evaluate cisco (*Coregonus artedi*) re-introductions to Keuka Lake, New York, an inland lake in the Lake Ontario basin. In recent years, managers have attempted coregonine restoration to improve forage resources throughout the Great Lakes basin, including Keuka Lake where cisco were extirpated. Since 2018, NYSDEC has stocked 450,000 juvenile cisco to restore a native prey fish community. We successfully demonstrated that small (< 1.0g) acoustic tags coupled with a whole-lake receiver array yields demographic estimates of juvenile survival useful for improving stocking practices. Specifically, we found that tagged fall fingerlings (age-0) experienced higher post-release mortality than tagged yearlings (age-1) with estimated 77% mortality for age-0 fish, compared to 30% mortality for age-1 fish, within 24-hours of stocking. Additionally, eDNA surveys revealed that cisco show 2- and 3-dimensional spatial preference within Keuka Lake at 12m and 18m vertical sampling depths, yet accurate inference of their distribution also required information from telemetry and lake current measurements. For example, a drifter survey of Keuka Lake found that currents moved widely, e.g., over 24-hours currents moved on average 1.88km at 12m depths and 0.86km at 18m depths. This research provides opportunities to improve population assessment of this fishery in Keuka Lake, with application to coregonine restoration elsewhere across the Great Lakes.

Nigarsan Kokilathasan, Basirath Raoof and Maria Dittrich, University of Toronto, Scarborough.
Photosynthetic Activity of Freshwater and Marine Picocyanobacteria under Nanoplastic Exposure.

An emerging threat to freshwater and marine environments is plastic pollution. Plastic debris can undergo weathering processes in aquatic systems to form nano-sized plastic particles, or "nanoplastics" (NPls), defined as plastic particles less than 1 μm. Due to their small size, NPls can cause adverse effects on cyanobacteria. The presence of NPls has been reported to deform cell morphology and impair photosynthetic activity through the sorption of NPls onto cell surfaces and induction of reactive oxygen species (ROS); excess ROS levels can damage DNA/RNA and membrane integrity. Picocyanobacteria genera *Synechococcus* are major primary producers in aquatic environments; in marine systems, *Synechococcus* contribute to ~20% of total primary production. Despite their significance, the impacts of NPls on the physiology and photosynthetic activity of *Synechococcus* have yet to be explored in depth. This study examines the effects of NPls at environmentally relevant concentrations on the physiology and photosynthetic activity of *Synechococcus*. Fluorometric and spectroscopic methods will measure photosynthetic activity and related parameters (i.e., chlorophyll concentrations) and determine the presence of ROS in NPl-

exposed cells. *Synechococcus* under NPl exposure will be visualized using microscopic methods to observe any potential sorption of NPls and deformation of cell morphology. The findings from this research will provide insights into the potential impacts of NPls on *Synechococcus* and primary productivity.

Sandra Kosek-Sills, Ohio Lake Erie Commission. **Research Components of the Ohio DAP.**

Research is an important component of the Ohio DAP because of the great size and complexity of the Lake Erie watershed, its ecosystem, and the human interactions with its landscape and water cycle. Resource managers in Ohio are faced with the challenge of managing a system with a large amount of uncertainty in its status, processes, and response. Adaptive management has been designed as a process for making decisions in such an uncertain system, but it requires an explicit research component in order to provide feedback to ongoing management. State agencies in Ohio have designed a series of actions in the Ohio Domestic Action Plan that are intended to reduce tributary nutrient loads with the objective of lake ecosystem responses of reduced severity of HABs and higher oxygen levels in deeper waters. This presentation will give an overview of the research program that supports Ohio's actions and discuss challenges of communicating this complex science information to stakeholders and the public.

Katya Kovalenko[1], Euan Reavie[1], Chris Filstrup[1] and Annie Scofield[2], [1]NRRI, UMD, [2]US EPA. **Fluorometry versus taxonomic phytoplankton assessments in the Great Lakes.**

Photosynthetic pigment fluorescence is commonly used in limnology and oceanography as a proxy for algal biomass. Fluorometry has been used to detect subsurface algal blooms, characterize dynamics of the deep chlorophyll layer and to provide greater vertical resolution to phytoplankton monitoring. However, more studies are needed to determine the accuracy of fluorometric assessment of different phytoplankton groups across a wide range of conditions. We combined basin-wide fluorometry data with simultaneously collected taxonomic data, assessed via microscopy, from the USEPA's Great Lakes Biological Monitoring Program to analyze the correspondence between the two approaches and to look for potential causes of any discrepancies. Fluorometric data consistently predicted total algal biovolume across the entire Great Lakes, but there was a much greater uncertainty at the lower end of the nutrient gradient. In the spring surveys, diatoms were detected with the greatest accuracy, with an intermediate accuracy for green algae and the lowest for cyanophytes and cryptophytes. We discuss the potential of this approach to increase our understanding of the structure of lower food webs in large lake systems. Greater vertical resolution of phytoplankton data is critical for assessing food web adaptive potential, especially where consumers may be approaching upper limits of their thermal tolerance.

Kurt Kowalski, Anders Hopkins, Margaret Jaenicke and Alexandra Bozimowski, U.S. Geological Survey. **Landscape-Scale Implementation of the Great Lakes Coastal Wetland Restoration Assessment.**

The Great Lakes Coastal Wetland Restoration Assessment (https://glcwra.wim.usgs.gov/) is an online geospatial decision support system designed to identify, assess, and prioritize areas along the U.S. coast of the Great Lakes that have the greatest potential for coastal wetland habitat restoration. In 2012, a collaborative group from the U.S. Geological Survey (USGS), University of Michigan, Nature Conservancy, National Oceanographic and Atmospheric Administration, and other agencies initiated a geospatial analysis of western Lake Erie that characterized the restorability of the coastal area from the Detroit River (Michigan) to the Black River (Ohio). Funding from the Great Lakes Restoration Initiative, the Upper Midwest and Great Lakes Landscape Conservation

Cooperative, and USGS supported expansion of the analysis to cover five other wetland-rich sections of the U.S. Great Lakes coasts: the Connecting River System around Lake St. Clair, Saginaw Bay (Lake Huron), Upper Lake Michigan, Green Bay (Lake Michigan), and Lake Ontario. Data from individual restoration assessments completed for each geography are available through a geonarrative and linked mappers. This analysis revealed extensive areas of potentially restorable coastal wetlands in western Lake Erie, Green Bay, and Saginaw Bay, with pockets of potentially restorable areas in the other geographies. Although a comparable analysis for the Canadian coastal area is not available yet, these products can be used in conjunction with the Great Lakes Coastal Wetland Decision Support Tool to support landscape-scale coastal wetland restoration.

Andrii Kramarenko and Rebecca Rooney, University of Waterloo. **Assessing Waterfowl Forage Quality change following invasive Phragmites suppression Using Vegetative Forage Quality Index.**

The Long Point and Big Creek National Wildlife Areas are essential wetland habitats in southern Ontario that serve as stopover sites for globally significant numbers of waterfowl. The Vegetative Forage Quality Index (VFQI), developed by Fleming et al. (2012) and modified by Farley et al. (2022), was used to monitor waterfowl forage quality during 2022-2023 in three vegetation types: *Phragmites australis*-infested, herbicide-treated *P. australis*, and uninvaded, reference vegetation. Plant species in each vegetation type were surveyed in August of both years using the point intercept method from 48 50-meter transects. A linear model was used to test for a change in index values depending on the factors of vegetation type, year and their interaction. VFQI values were variable between years and among the three vegetation types, but we did not detect a significant interaction between year and vegetation type. Indeed, the full linear model was not supported by the data: R^2 = 0.078, and is not statistically significant ($F_{5,90} = 1.518$, $p = 0.1922$), suggesting that herbicide application to suppress invasive *Phragmites* did not enhance forage quality. However, only about 50% of the identified species had published values of the C coefficient for the vFQI calculation, limiting our ability to assess change. We conclude that the development of coefficients for regionally common plants has the potential to render the vFQI more useful to wetland managers and decision-makers interested in enhancing waterfowl habitat quality.

Benjamin Kramer[1], Anders Kiledal[2], Arthur Zastepa[3], Thomas Bridgeman[4], Reagan Errera[5] and Cody Sheik[1], [1]University of Minnesota Duluth, [2]University of Michigan, [3]Canada Centre for Inland Waters, [4]The University of Toledo, [5]NOAA. **The genome characteristics and distribution of Dolichospermum circinale in the Great Lakes.**

Harmful cyanobacterial blooms have and continue to be a serious ecological and human health concern in the Great Lakes region. While the cyanobacterial communities of such blooms are often dominated by *Microcystis*, particularly in Lake Erie, there are notable exceptions. In November 2022 a bloom of the Nostocales genus *Dolichospermum* covered a substantial portion of Western Lake Erie. This taxon was successfully isolated in culture and retains its ability to form heterocysts and fix dinitrogen (N_2). Here, we describe the genomic and phylogenetic characteristics of this Nostocales species, identified as *Dolichospermum circinale*, along with those of another species of this genus, identified as *Dolichospermum heterosporum*, which was isolated from a cyanobacterial bloom in Lake Erie in 2011 and has since lost its ability to form heterocysts and fix N_2. AntiSMASH results characterize both genomes' biosynthetic gene clusters associated with the production of secondary metabolites. Using the Great Lakes Atlas of Multi Omics Research (GLAMR), we also characterize the abundance and distribution of both taxa across the Great Lakes. Collectively, these data provide

valuable insight in regard to the potential of bloom-forming members of this genus to dominate the cyanobacterial communities of the Great Lakes.

Dan Kraus, Robyn Rumney and Ciara Raudsepp-Hearne, Wildlife Conservation Society Canada.
Identifying Key Biodiversity Areas to support wetland conservation in the Great Lakes.

Key Biodiversity Areas (KBAs) serve as crucial focal points for preserving biodiversity, with standardized global criteria established by the International Union for Conservation of Nature and complemented by national criteria from the KBA Canada Coalition. Great Lakes wetlands include many species and ecosystems that trigger KBA identification. These include globally and nationally threatened species and ecosystems and seasonal aggregations of birds and fishes. Currently, the Great Lakes basin has approximately 100 KBAs, with wetlands including Greater Rondeau Area, Eastern Georgian Bay, and Eastern Lake St. Clair either identified or under consideration. KBAs are not prescriptive but serve as a tool to help guide land use planning and sustainable development, the establishment of protected and conserved areas, and to inspire community efforts to protect nature. In Canada, KBAs are being identified through a 'bottom-up' approach that incorporates local and Indigenous knowledge. KBAs highlight Great Lakes wetlands that contribute to global and national biodiversity targets and provide important ecosystem services to local communities. This presentation will provide an overview of KBAs, and showcase select wetland KBAs in the Great Lakes. Our discussion will explore the potential of leveraging Great Lakes KBAs to direct community-based conservation and restoration efforts, as well as to enhance wetland monitoring.

Joseph R. Krieger and Deborah H. Lee, NOAA GLERL. **NOAA GLERL's Role in Supporting Initiatives to 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. Over the years, staff from NOAA's Great Lakes Environmental Research Laboratory (GLERL) have played a critical role in helping to address aquatic invasive species both in the Great Lakes and across the country. Now, GLERL serves as the national point of contact for NOAA's invasive species mission. 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 how NOAA's work with invasive species helps support strategic initiatives both in the Great Lakes and across the country.

Brandon Krumwiede, National Oceanic and Atmospheric Administration Office for Coastal Management. **Looking Below the Surface: An Update on Benthic Habitat Mapping in the Great Lakes.**

Over the last few years, the National Oceanic and Atmospheric Administration, together with multiple partners, has been working to collect new coastal and nearshore high-resolution bathymetry, multibeam backscatter, and lidar reflectance to support the classification and mapping of benthic habitats within the Great Lakes, funded through the Great Lakes Restoration Initiative. Bathymetric lidar and multibeam sonar are used to collect these foundational data, and combined with underwater video and ancillary data, are used to derive new and updated classification of the

substrate, biotic, and geoform components using the Coastal and Marine Ecological Classification Standard, or CMECS. This presentation will focus on providing an overview of the work completed to date and the potential opportunities for use of these new data, and information to inform water ecosystem restoration and protection efforts.

Anna Kryshak[1], Harvey Bootsma[1], Brenda Lafrancois[2] and Jacques Rinchard[3], [1]University of Wisconsin Milwaukee, [2]National Park Service, [3]SUNY Brockport. **Depth gradients in nearshore benthic food web structure in Lake Michigan.**

In Lake Michigan, nuisance benthic algal blooms have been a prominent management issue associated with the introduction and proliferation of dreissenid mussels. Dreissenid mussels have altered nutrient cycling and decreased phytoplankton abundance in the lake, which may have increased the importance of benthic algae as a food source for benthic primary consumers. Because light and nutrient availability are two key factors affecting the abundance and nutritional quality of algae, and these factors vary seasonally and spatially, we hypothesized that food web structure varies with season and depth within the nearshore region. We measured benthic algal nutritional quality (as phosphorus and fatty acid content) and benthic trophic pathways (as revealed by stable C and N isotopes) over a 5-20 m depth range. Algal biomass and phosphorus content varied both seasonally and with depth, with biomass tending to decrease and phosphorus content tending to increase from July to October and with increasing depth. Preliminary data indicates that carbon stable isotope ratios vary both seasonally and with depth for algae, benthic invertebrates, and round gobies, but not mussels. Our results thus far suggest complex seasonal and spatial (depth) variation in the structure of the nearshore benthic food web

Jayson Kucharek[1, 2], Paige Arieno[1, 2], Nikki Fuller[1, 2], Evan Batte[1, 2], Steven Day[2, 3], Christy Tyler[1, 2] and Matthew Hoffman[2, 4], [1]Gosnell School of Life Sciences, [2]Rochester Institute of Technology, [3] Department of Biomedical Engineering, [4]School of Mathematics. **Mass balance modeling of anthropogenic debris in the Lake Ontario Watershed of Rochester, NY.**

Stormwater-driven input has been found to be a major contributor of anthropogenic debris to the environment in the Great Lakes region. The goal of this project is to derive an anthropogenic debris budget across the Lake Ontario watershed in the Rochester, NY, metropolitan area, with a focus on stormwater transport. A regression model was developed using data on debris input and accumulation collected from storm drains, tributaries, riparian zones, and stormwater ponds over a two-year period. The debris was collected, weighed, sorted by material, and characterized by use. These input and accumulation data were combined with anthropogenic and land-use variables to derive the model output. The model will be used for a regional mass balance and also provide a detailed budget that allows us to predict hotspots of debris input and better understand heterogeneity in types of debris and seasonal input. Model results can also be used to inform local policymakers and inspire residents to take action to limit the amount of debris entering our environment.

Burak Kuyumcu[1], Leon Boegman[1], Shiliang Shan[2], Wei Shi[1], Yingming Zhao[3], Zachary Amidon[4], Josef Ackerman[5] and Edward Roseman[6], [1]Environmental Fluid Dynamics Laboratory, Department of Civil Engineering, Queen's University, [2]Department of Physics and Space Science, Royal Military College of Canada, [3]Aquatic Research and Monitoring Section, Ontario Ministry of Natural Resources and Forestry Lake Erie Fishery Station, [4]University of Toledo, Lake Erie Center, Department of Environmental Science, [5]Physical Ecology Laboratory, Department of Integrative

Biology, University of Guelph, [6]U.S. Geological Survey Great Lakes Science Center. **Modelling the fate of Walleye eggs in western Lake Erie using a particle tracking model.**

Walleye (*Sander vitreus*), which support a billion-dollar fishery in Lake Erie, have a crucial role in determining ecosystem community dynamics. Understanding the recruitment of walleye is critical for developing effective fishery management strategies, and hydrodynamics influence recruitment by controlling the transport of eggs and larvae. For example, current and wave-induced shear stresses during storm events may cause egg mortality and/or resuspension and transport to unsuitable substrates. We applied a backward particle tracking model and temperature-dependent growth models to estimate the hatching locations associated with walleye larvae observations. We also applied temperature and substrate dependent spawning and egg growth models to determine when walleye eggs were located on reef sites. Egg mortality, resuspension, transport, and settling were calculated from bed shear stresses based on both mean current and wave orbital velocities using parameters derived from laboratory data. The findings of this study will enhance the understanding of walleye recruitment dynamics by quantifying the impacts of hydrodynamic processes on egg hatching success. Future work will include forward particle tracking of hatched larvae, combined with a larval growth model, to ultimately evaluate if the projected match-mismatch between first-feeding larvae and forage could account for temporal variations in recruitment.

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Greg LaBarge, Ohio State University Extension. **Agricultural P Nutrient Use Changes in the WLEB Watershed.**

Total P nutrient applications per acre have decreased since the mid-90s in Ohio Western Lake Erie Basin (WLEB) counties. A 48% reduction occurred in average annual applications from 1994-1998 (the five highest use years) to 2018-2022 (the most recent period), where an estimated 24,500 tons of P2O5 was applied annually from all nutrient sources. The reduction in nutrient application paired with increased yield for grain and forage crops has resulted in a net removal of P2O5 in the basin. Since 2003, the average net P2O5 removal is 11 pounds per acre. Soil Test P (STP) data for the region supports this observation of net removal where most counties show a declining median STP when comparing 1995 to 2015 data. Reduced P applications result in less P exposed to acute losses at application plus, observed trends in STP which over time should impact chronic P loss, are encouraging agricultural trends in meeting WLEB P eutrophication goals.

Britta Larson[1, 2], Chan Lan Chun[1, 2], Molly Mikan[2], Christopher T. Filstrup[2], Euan D. Reavie[2] and Matthew J. Berens[2], [1]University of Minnesota Duluth, [2]Natural Resources Research Institute. **Spatial and Temporal Variability of Sediment Microbial Communities Affect Biogeochemical Processes in Lake Superior.**

Sediment microbial processing influences organic matter degradation, nutrient cycling, and the fate and transport of contaminants in aquatic ecosystems. However, gaps still exist about the coupling strength among biogeochemical cycles, as well as how that strength varies over environmental gradients. As part of the Great Lakes Sediment Surveillance project, we investigated the spatial and temporal variability of prokaryotic communities in sediments throughout Lake Superior. Basin-wide surface sediments and sediment cores were collected to characterize prokaryotic communities with geochemical profiles. Phylogenetic composition and functional traits of the potentially active (RNA-based) community compared to the total (DNA-based) community highlight taxa that contribute to geochemical processes in surface sediment. Overall prokaryotic

communities of surface sediment were largely composed of aerobic, catalase-, and oxidative-positive genera using organic compounds and driving nitrification and ammonia oxidation. Moreover, sediments collected from the entrances of tributaries had more unique community structures than those from open water. Total prokaryotic community composition in sediment cores shows the change in past and present prokaryotic communities. This research is being applied to other Great Lakes, providing a unique opportunity to study how microbial composition and functions compare under variable environmental conditions and stressors across the Laurentian Great Lakes.

Ryan Lauzon[1], **Breanna Redford**[1], **Michele Desjardine**[1], **Erin Dunlop**[2] and **Courtney Taylor**[3], [1]Chippewas of Nawash Unceded First Nation, [2]Ministry of Natural Resources and Forestry, [3]Trent University. **A two eyed seeing approach to understand rapidly evolving food web dynamics in Lake Huron.**

Western scientists and Indigenous knowledge holders have noticed many concerning changes happening in Lake Huron that are symptomatic of the rapidly evolving changes in food web dynamics in Lake Huron. These changes are suspected to be a result of the complex interplay between multiple drivers such as invasive species, climate change, fish stocking, shoreline development, etc. A good example of these changes is the increasing predation and competition between Nmego (*Salvelinus namaycush*) and dikameg (*Coregonus clupeaformis*) noticed by Saugeen Ojibway Nation (SON) knowledge holders in Lake Huron. The SON are concerned that these increased interactions are partly responsible for the concerning dramatic decrease in dikameg. In response to these concerns the Chippewas of Nawash Unceded First Nation fisheries assessment program and the Ministry of Natural Resources and Forestry embarked on a three-year research project with funding from the Great Lakes Fisheries Commission to better understand this question. The following presentation will provide a description of the project, some preliminary results, and the underlying two-eyed seeing methodology used to bridge Western Science and Indigenous knowledge applied in this research project. The primary goal for this presentation is to provide an example of successful collaboration between a First Nation and a Government Agency to encourage other similar research partnerships.

Sarah Lavoie-Bernstein[1], Liisa Jantunen[2], Miriam Diamond[1] and Paul Helm[3], [1]University of Toronto, [2]Environment and Climate Change Canada, [3]Ontario Ministry of the Environment, Conservation and Parks. **Comparing Sampling Methods for Measuring Atmospheric Microplastics in Rural and Urban Sites, using Laser Direct Infrared Spectroscopy (LDIR).**

In recent years, there have been growing concerns regarding atmospheric-related microplastics and anthropogenically sourced particles. Atmospheric transport disperses these particles quickly and worldwide, deposition being an important source to terrestrial and ocean surfaces. Traditional air sampling methods were deployed and compared during this study, to investigate atmospheric-related microplastics and anthropogenically sourced particles using; active-air, bulk deposition, and wet deposition. Samples were deployed in a densely populated urban centre and at a rural site in southern Ontario, between February 2022 and February 2023. The overall number of particles and the diversity of polymer type and morphology were higher at the urban site. More fragments were collected at the urban site, while fibres dominated the rural site. The dominant polymer types at both sites were polyester, polypropylene, and anthropogenically modified cellulose (e.g., denim, cellulose acetate, etc.). There was no statistical difference between the sampling methods used at either site ($p > 0.05$). This implies that the simple bulk deposition samplers can be confidently used to determine the abundance and the diversity of polymer types and morphology in ambient air.

Sarah Lawhun[1], James Watkins[1], Lars Rudstam[1], Lyubov Burlakova[2] and Alexander Karatayev[2], [1]Cornell University, [2]Buffalo State University. **As Different as Night and Day: Using ponar counts to assess Mysis benthic habitat use.**

During Mysis diel vertical migration, most individuals migrate towards the thermocline at night while others remain in the benthos. The proportion of Mysis exhibiting partial migration has not been quantified and is missed by net-based monitoring programs. Light and temperature primarily drive Mysis migration but other factors including intraspecific competition may keep some individuals in the benthos both day and night. Additionally, at sites deep enough to meet Mysis light and temperature preferences, Mysis may not migrate to the benthos at all. Using ponar Mysis counts provided by Buffalo State University as part of the EPA GLNPO long-term monitoring and CSMI lakewide surveys, Mysis benthic habitat use can be evaluated by identifying areas with high number of Mysis in the benthos, and whether high density areas are different between day and night. Corresponding drop-down video footage was used to confirm the effectiveness of the ponar sampling approach. Pelagic net tows also corresponding to ponar sites were used to evaluate the proportion of the total population remaining on the bottom at night. If significant numbers of Mysis remain in the benthos at night, monitoring programs relying on nighttime pelagic net tows will be biased low.

Ted Lawrence, African Center for Aquatic Research and Education. **The influence of colonization on research of freshwater lakes of Africa: Breaking the cycle.**

The African Great Lakes (AGL) consist of over 28% of the world's surface freshwater. They support millions of people's livelihoods and their riparian governments reap large benefits. These resources face the same challenges as other freshwater resources the world over. What is surprising, is the relative lack of resources directed towards addressing such problems. The lack of resources is caused, in part, by colonial approaches to development and natural resource research and management. These approaches keep financial power and influence, and research directives, centered in the "global north". Such approaches are actually detrimental to understanding these resources through short-term, disparate, and underfunded efforts. The results are inadequate and inconsistent monitoring of even basic parameters, incomplete information and data, barriers to accessing data and information relevant to these resources, and a dearth of in-field training opportunities for African scientists. There must be a shift from the present reliance on international and top-down approaches to funding and research, to long-term comprehensive processes that give agency to the African scientific community. Herein, I discuss how this can be done by creating "dense" networks of scientists who establish harmonized and prioritized research needs on each of the AGL--empowering those on the ground to direct those who desire to conduct research in this region. This concept creates the "voice of science" and flips the top-down "bungee" approach to a bottom-up process.

Kevin Obiero[1] and **Ted Lawrence**[2], [1]Kenya Marine Fisheries Research Institute, [2]African Center for Aquatic Research and Education. **African Great Lakes Status and Research Needs: A Special Section of the JGLR.**

During 2021-2023, over 100 African freshwater experts from the ten riparian countries of the seven African Great Lakes, produced a special section in the Journal of Great Lakes Research (JGLR) highlighting the importance of these critical lake resources of eastern and southeastern Africa. The special section goes beyond specific research studies on each of the lakes and focuses on the overall research and knowledge gaps that must be addressed to escape the knowledge doldrums that exist because of a lack of attention, research and financial resources, infrastructure, and

disparate approaches to these lakes. These papers will, in part, help the local, regional, and international research communities and those who support such efforts, guide the way forward for much needed information to make good management and policy decisions to sustainably protect these lakes, their resources, and thus the millions of people who rely on them.

Deborah Lee, NOAA's Great Lakes Environmental Research Laboratory. **GLERL at 50 - A Review of Fifty Years of Science in Service to Society.**

The NOAA Great Lakes Environmental Research Laboratory (GLERL) was created in 1974 to "conduct research directed toward an understanding of the environmental processes in the Great Lakes and their watersheds." GLERL's freshwater focus on the Great Lakes, large lakes of the world, and coastal ecosystems, with a mission of transitioning science for prediction and ecosystem management, makes GLERL unique. For 50 years, GLERL's research has contributed to products and services that protect lives and livelihoods, the economy, and the environment of the Great Lakes region. Our approach to scientific research—integrated around physical, chemical, and biological interactions—serves as a framework to address the complex environmental challenges posed by the uncertainty of human-induced stressors and a changing climate. This integrated approach builds upon long-term observations, data collection, experimentation, modeling, prediction, and forecasting. GLERL's most significant research accomplishments over the past 50 years and their impact will be presented.

Deborah Lee, NOAA's Great Lakes Environmental Research Laboratory. **GLERL at 50 - Looking Ahead: The next 50 Years of Science in Service to Society.**

The NOAA Great Lakes Environmental Research Laboratory (GLERL) is committed to protecting and securing Great Lakes water and ecosystem resources for current and future generations. GLERL will continue its integrated physical, chemical, and biological research to address the most pressing environmental challenges. This talk will present new novel partnerships, innovative observing technology, cutting-edge experimental research, the development of advanced physical and ecosystem models and the use of social science to deliver useful applications to society. New research areas and initiatives include freshwater oil spill modeling, 'omics, winter hydrology, Great Lakes acidification, the Climate, Ecosystems and Fisheries Initiative, the Coastal Inundation and Flood Mapping Initiative, and Developing the Next Generation Prediction System for Great Lakes Water Levels and Lake Management Decisions.

Deborah Lee[1] and Rebecca Knoche[2], [1]NOAA Great Lakes Environmental Research Laboratory, [2]NOAA GLRI Program Coordinator, Groundswell. **Delivering Science, Service and Stewardship: Insights on Governance and Management of Complex Science Programs.**

Successfully conducting the proposed Great Lakes Decadal Science Plan will need to be underpinned by a strong governance system coupled with federal authorities and programs. The governance system must be inclusive of a wide variety of perspectives, oversee science planning, facilitate collaboration, be accountable for execution, and communicate results. Federal authorities and programs (new or existing) are required to move federal appropriations and investments to those who will do the research and on-the-ground work: federal, state/provincial and indigenous agencies, academia, non-governmental organizations and contractors. NOAA's delivery of science and habitat restoration under the U.S. Great Lakes Restoration Initiative (GLRI) serves as one potential delivery model. Since 2010, NOAA has executed over $355M of GLRI funding, consistently ranking in the top 5 of the 16 participating U.S. federal agencies in terms of funding. NOAA has leveraged its multiple authorities and programs to bring in partners to help conduct the

work, including cooperative agreements with regional partners and academic institutes, grants, contracts and existing programs such as Sea Grant and the Bay Watershed Education and Training (B-WET) Program. Insights on the governance, management and delivery of a complex science and restoration program will be presented. Some additional thoughts on how to scale this to a binational program will also be presented, based on the author's experience with several multi-year, multi-million-dollar International Joint Commission studies.

Kenneth Lee, Kenneth Lee Research Inc. **The Need to Advance Oil Spill Science and Response Strategies for Inland Waters.**

Media attention on oil spills typically focuses on large-scale marine incidents, overshadowing the significant impact of smaller volume freshwater spills on both the environment and society, especially in regions dependent on uncontaminated drinking water and subsistence living. As exploration/production and transport of oil and refined products by pipeline, rail, trucks, barges, etc., has increased to meet our energy demand, the risk of accidental releases into Canada's inland waters is now greater. Advancing oil spill science is imperative to understand the risks and develop effective strategies to mediate/remediate their potential detrimental effects. Oil spill response methods used for oil spills in the marine environment may not be acceptable nor effective for spills in lakes or rivers due to differences in environmental and socioeconomic factors. Addressing freshwater oil spill challenges requires a comprehensive approach, combining scientific insights with strategic planning to safeguard both environment and society. Canada's Multi-Partner Research Initiative has identified the need to advance research in the following key areas: 1) fate, behaviour and transport of oil in the environment, 2) Alternative response measures, 3) oil detection and monitoring, 4) biological effects of oil, 5) physical recovery of oil, and 6) planning and decision-making. This research aims to guide effective responses, accelerated habitat recovery, and minimize long-term environmental consequences.

Laura Legzdins, Manomin Project team. **The Manomin Project.**

To combat the decline of a culturally significant crop in the Lake of the Woods watershed due to settler hydrological changes, Niisaachewan Anishinaabe Nation and University of Guelph researchers are investigating freshwater restoration and research practices which weave Indigenous Knowledge Systems with Western Science. Manomin, also called wild rice (*Zizania palustris*), is known as "the food that grows on water" and "the good berry" by the Anishinaabeg, as healthy relationships with the annual macrophyte ensure food, economic and cultural security. Extensive damming of waterways in what is known as Northwestern Ontario, Canada greatly influences the ecological integrity of fluvial systems and can result in drastic declines in plants like Manomin. Elders at Niisaachewan Anishinaabe Nation estimate that contemporary yields have declined by 99%. The Manomin Project is a multicultural, multidisciplinary research team committed to crop restoration and cultural revitalization in Anishinaabe-Aki, the land of Anishinaabeg. Niisaachewan Anishinaabe Nation and University of Guelph researchers are collaboratively developing culturally appropriate freshwater crop restoration strategies which align with Anishinaabe understandings of Human-Plant relationships. Culturally appropriate restoration weaves Anishinaabeg horticultural precedents with Western plant science to guide practices which support the revitalization of Manomin and Anishinaabeg lifeways. This dialogue is crucial as it speaks to the restoration of native crops and Indigenous stewardship, both of which are essential and inseparable in environmental care.

John Lenters[1], Peter Blanken[2], Newell Hedstrom[3], Erin Nicholls[3] and Chris Spence[3], [1]University of Michigan, [2]University of Colorado-Boulder, [3]Environment and Climate Change Canada. **Advances in Year-Round Hydroclimatic Data: 16 Years and Counting for the Great Lakes Evaporation Network.**

Lake evaporation is one of the most important physical processes of a lake ecosystem, affecting everything from water levels and stratification to ice cover, aquatic chemistry, and regional weather and climate. Yet prior to 2008 there were no direct measurements of evaporation over the Great Lakes, presenting a significant gap in knowledge for large-lake science, policy, and adaptive management. It was the hydrologic community within the International Joint Commission that helped launch the first, direct measurements of Great Lakes evaporation via the installation of a year-round monitoring station on Lake Superior in 2008. In subsequent years, and through the collaborative effort of eight institutions, two countries, and multiple funding sources, the monitoring network grew to seven stations across all of the Great Lakes, thereby establishing the "Great Lakes Evaporation Network (GLEN)." Similar to other land-based flux towers, the GLEN sites use the eddy covariance method to calculate fluxes of heat, momentum, and water vapor (i.e., evaporation), providing one of the most comprehensive, year-round observational datasets of Great Lakes hydroclimate. In this presentation, we provide an overview of GLEN, discuss the significant role it has played in supporting adaptive management (e.g., improving forecasts of water levels and lake-effect snowfall), and describe recent advances in instrumentation and data communication / management at the two longest-running sites on Lake Superior, one of which is now part of the AmeriFlux network (Stannard Rock lighthouse).

Nancy Leonard, Pacific States Marine Fisheries Commission. **Effective Mentoring 'a la' Taylor Style.**

Mentors, Leaders, and Teachers can, and do, all have different styles and skillsets that allows them to be best suited for different mentees. Most tend to bring forth a specific set of expertise that they can share with their mentees and will have varying strengths and weaknesses related to communication and interpersonal skills. Being not only a mentee of Bill Taylor, but working along side him for 6years as his official 'handler', provided me with the opportunity to observe, and learn from, the unique ' a la' Taylor Style approach to mentoring and its success with a much broader range of personalities, expertise, project range, that one would not normally expert to all fit the same mentor. I will share some of the secrets of the successful 'a la' Taylor mentoring style that I, and many others, have benefited from drawing on short (maybe funny) stories to highlight.

Ryan Lepak[1], Grace Armstrong[2], Sarah Balgooyen[3], Michael Mahon[1], Michael Tate[2] and Sarah Janssen[2], [1]United States Environmental Protection Agency Office of Research and Development, [2]United States Geological Survey Mercury Research Laboratory, [3]SpecPro Professional Services. **Connecting energetic subsidies to contaminants to better understand contaminant fate and transport in Lake Huron.**

In Lake Huron, changing nutrient regimes, resulting from intentional mitigations and presence of invasive species, are directly impacting the availability of basal-level subsidies which generate nutritional shifts in the food web that can influence fish health. Considering the nearshore and benthic realms in particular, contaminant dynamics are changing in multidimensional ways, independent of the nutritional shifts but in some instances following the nutrient shifts. Specifically, certain legacy compounds are declining in emissions, like perfluorooctane sulfonic acid and mercury, but are not necessarily declining in the context of fish contaminant burdens, potentially due to shifting dietary sources and growth rates. In contrast our understanding of the ecological importance

of newer compounds (e.g., next generation perfluoroalkyl and polyfluoroalkyl substances) that are becoming increasingly prevalent in the environment, remains poor. We designed a spatially comprehensive sampling program to measure the aforementioned contaminants in water, biota and sediment, and determined energetic subsidies (using isotope ecology) to empirically resolve contaminant bioavailability, fate and transport in Lake Huron. In this discussion, we will review the early results of our 2022 efforts and contextualize them historically using recent results produced on a long-term fish archive managed by EPA. Further, we aim to continue using this multi-faceted approach in each of the Great Lakes by leveraging the spatially comprehensive sampling performed during each CSMI effort to construct Great Lakes-wide models.

George Leshkevich, NOAA Great Lakes Environmental Research Laboratory Retired. **Great Lakes CoastWatch Operations, Remote Sensing Research, and Product Development- 1990 - 2018.**

Although remote sensing research and product development occurred at the Great Lakes Environmental Research Laboratory (GLERL) before 1990, becoming the National Oceanic and Atmospheric Administration (NOAA) CoastWatch regional node for the Great Lakes, charged with obtaining, producing, and delivering environmental data and products for near real-time monitoring of the Great Lakes, increased the opportunity to develop products using the array of satellite data then becoming available. Using satellite and airborne visible , infra-red, thermal, radar, and scatterometer data, several image products of use to operational, research, academic, recreational and other users, including Great Lakes full-field surface temperatures, ice type classification and thickness range, chlorophyll/CDOM/suspended mineral, upwelling, and wind speed/direction(obtained), were developed and made available to users via the Great Lakes CoastWatch website (https://coastwatch.glerl.noaa.gov). Databases, created from in situ measurements, for algorithm development and product validation include the polarometric C-band radar ice type backscatter database, the inherent optical property/apparent optical property (IOP/AOP) with concurrent water chemistry database, and the under ice types PAR light attenuation database. In addition, techniques developed upon request include real-time shipboard drone ice monitoring for US Coast Guard ice breaking operations and airborne ice thickness measurements using ground-penetrating radar, a demonstration with the Canadian Coast Guard.

Ryan Leung[1], Neil Rooney[1], Ryan Prosser[1] and Bob Hanner[2], [1]University of Guelph, School of Environmental Sciences, [2]University of Guelph, Department of Integrative Biology. **Integrating Ecotoxicological and eDNA approaches to Assess Net-Pen Aquaculture Waste Impact on Benthic Invertebrate Communities.**

Net-pen aquaculture is poised to expand in Ontario to meet increasing demand for fish-sourced protein. Solid waste deposition on the sediment from net pens is a primary environmental concern for ecosystems in general, and benthic invertebrate communities specifically. While the fish waste deposited in benthic environments represents a potential food source for invertebrates, the communities are also potentially exposed to stressors such as anoxia and waste-associated contaminants. In order for the industry to expand in a sustainable manner, therefore, the dose-response characteristics of benthic communities to fish waste need to be defined. The present study aims to determine the assimilative capacity of benthic invertebrates of solid waste deposition (i.e., the maximum amount of solid waste they can assimilate and process without harmful effects). Traditional biodiversity assessment and eDNA metabarcoding will be employed to characterise the *in-situ* biodiversity of the benthic invertebrates along a transect moving away from a rainbow trout net-pen operation. Laboratory-based sediment ecotoxicological bioassays will be performed to

quantify the growth, reproduction, and survival of benthic invertebrate species exposed to varying levels of solid waste deposition. Using results from both the *in situ* eDNA and ecotoxicological studies, a structural equation modelling approach will be used to derive estimates of assimilative capacity. The results of this research will provide the basis for an evidence-based approach to establishing the assimilative capacity of benthic invertebrate communities near freshwater fish farms.

Matthew W. Lewandowski Jr, Hunter Roose, Gordon Paterson and Jill A. Olin, Department of Biological Sciences, Great Lakes Research Center, Michigan Technological University, Houghton, MI. **Temporal trophic dynamics in a stream fish assemblage using stable isotope analysis.**

Identifying how animals use available prey resources and the environmental and ecological drivers of resource use are fundamental for effective species and ecosystem management, as well as to protect important foraging grounds and prey resources supporting species productivity. In streams, secondary production is supported by autochthonous (*i.e.*, algae, periphyton, and bryophytes) and allochthonous (*i.e.*, leaves and detrital material) inputs, and the heterogeneous availability of these resources can affect species resource use. For example, in temperate streams autochthonous production is typically higher in spring, and shifts to a more allochthonous system with the onset of riparian vegetation growth in early summer. This transition potentially alters the relative contributions of both subsidies to in-stream consumer species. The objective of this research is to examine the trophic diversity and degree of trophic overlap among fishes of the Salmon-Trout River, located in Michigan's Upper Peninsula, using bulk-tissue stable isotope analysis of carbon and nitrogen ($\delta^{13}C$ and $\delta^{15}N$). Specifically, we compare the isotopic niches of seven fish species (*Salvelinus fontinalis*, *Oncorhynchus mykiss*, *Catostomus commersonii*, *Cottus* spp., *Semotilus atromaculatus*, *Umbra limi*, *Rhinichthys cataractae*) sampled via electrofishing techniques and use Bayesian mixing models to quantify the relative contributions of autochthonous and allochthonous energy pathways. We then compare these metrics across seasonally sampled assemblages (June and September) to determine if varying contributions of these resource subsides alter the trophic linkages.

Eric Li, Shayenna Nolan and Catherine Febria, University of Windsor. **Carbon characterization as a tool for detecting human impacts on wetlands and streams across the land-water interface.**

Human impacts on the Earth's ecosystems are now so pervasive that the UN has declared 2021-2030 the Decade of Ecosystem Restoration, building on the growing global acceptance that degraded ecosystems are not fully recovering and human-driven climate change has placed us in a 'code red' state of emergency. Agriculture and urbanization are some of the most prevalent human impacts affecting freshwater ecosystems in the Great Lakes Basin, particularly in southwestern Ontario, which has suffered historic rates of wetland loss and headwater stream burial. These habitats are hotspots of carbon transformation and storage and understanding how human impacts have affected these key ecosystem processes is necessary for targeted restoration efforts. In this study, we compared human impacted streams and wetlands to reference conditions (n=12) to quantify changes in carbon quantity and quality. Using fluorescence spectroscopy of dissolved organic matter (DOM) alongside other ecosystem indicators (N, P), in water samples and water-extractable organic matter (WEOM) from sediment and soil samples, we interrogate the extent to which carbon-based indicators can be used to compare human impacts in urban and agricultural landscapes. This work extends a baseline for the region to inform and mobilize restoration actions on the ground, and ultimately as a tool to help re-connect land, water, and people.

Lin Li, Chentong Feng, Yanxia Zuo, Qi Zhang, Lingling Zheng and Lirong Song, Institute of Hydrobiology, Chinese Academy of Sciences. **Investigation of off-flavour episodes and characteristics of earthy/musty odor producers in some lakes and reservoirs in China.**

Off-flavour problems in freshwater caused by 2-methylisoborneol (MIB) and geosmin have attracted much attention in China in the past two decades. Off-flavour episodes occurred in an eutrophicated lake, a drinking water reservoir and an integrated constructed wetland-reservoir system (CWR) and earthy/musty odor producers were investigated. Lake survey showed that the concentration of particulate geosmin correlated significantly with the biomass of *Dolichospermum*, while the concentration of particulate MIB correlated significantly with the biomass of *Planktothrix*. Annual study in Xionghe reservoir revealed that the geosmin peak in July was significantly associated with the abundance of *Dolichospermum*, while high content of MIB in April was significantly associated with the amount of *Pseudanabaena*. Moreover, High concentrations of geosmin (up to 5280 ng kg^{-1} dw^{-1}) were detected in sediments, and eight strains of *Streptomyces* isolated from sediments were verified as producers of geosmin and/or MIB by HSPME-GC-MS. Geosmin concentrations in the overlying water were correlated with those in the sediments ($r=0.838$, $p < 0.05$). In vitro studies showed that geosmin in the overlying water was released from the sediment. It indicates that odorous compounds that are released from sediments might be taken into account. Another study in CWR oberserved two peaks of MIB, attributed mainly to *Pseudanabaena* in April, and *Pseudanabaena* and *Oscillatoria* in July. This indicated that benthic filamentous cyanobacteria is also a threatening factor and should be considered.

Shuqi Lin, Jun Zhao, Yongbo Liu and Reza Valipour, Environment and Climate Change Canada. **The impact of ice model on the multi-year water quality simulation in Lake Winnipeg.**

The 3-dimensional lake model could help to investigate the lake ecosystem dynamics comprehensively. With the embedded ice model, the lake model AEM3D can simulate the ice phenology in a large lake (Lake Winnipeg, Canada), and conduct a multi-year water quality simulation. This study applied the model to simulate 3-year hydrodynamics and water quality in Lake Winnipeg, spanning two and a half winter seasons. According to the sensitivity test, the ice model is sensible to snow depth input, snow/ice albedo and snow/blue ice/white ice visible extinct coefficients. Snow depth input is essential for white ice generation and affects the modeled ice-off date and total ice thickness. In Lake Winnipeg, the ice-on/off date largely affects the nutrient distribution and circulation. In the northern basin, dissolved oxygen (DO) keeps decreasing under ice during the winter, potentially leading to the internal loading of nutrients from bottom sediments. Therefore, the ice-off date, determining the timing of vertical mixing of water column, affects the extent of hypoxia at the bottom. The observations and the model results show that DO concentration decreased to less than 2mg/L in the most parts of the northern basin during winters, and hypoxia grown from nearshore regions to pelagic regions. The model results present the most severe hypoxia happened in late May and early June when the ice cover was just about to disappear.

Yuanyuan Lin[1], Xuexiu Chang[1], Xiaowei Zhang[2], Zheng Zhao[1], Shan Xu[1], Liang Shen[1], Wenjun Zhong[2] and Han Meng[1], [1]Kunming University, [2]Nanjing University. **Impacts of anthropogenic activities on phytoplankton and fish communities in Dianchi Basin via eDNA biomonitoring.**

As the most important producers and consumers of aquatic ecosystems, phytoplankton and fish were closely related to aquatic ecological environment and have been widely used in ecological assessment of aquatic environments. Combining advantages of DNA-based identification and high-throughput sequencing technology, eDNA biomonitoring permits a new measurement for

biodiversity monitoring in aquatic ecosystems. However, it had rarely been used to explore phytoplankton and fish community responses to environmental factors in Dianchi Basin. Via eDNA biomonitoring, this study investigates the spatial and seasonal distributions of phytoplankton and fish communities and the environment stressors of Dianchi Basin (including Dianchi and its main inflow rivers Panlong River, Baoxiang River and Chai River). 243 distinct phytoplankton taxa and 41 fish species were detected. Distinct spatial and seasonal variations of phytoplankton and fish community patterns (e.g., community composition, dominant taxa, α-diversity) were observed among the sampled habitats. The patterns of phytoplankton and fish diversity were closely related to environmental factors, which were associated with pollution sources from different anthropogenic activities (e.g., urbanization, water diversion, industrial and agricultural activities). And interestingly, the first dominant cyanobacteria genus was changed from *Microcystis* (dry season) to *Planktothrix* (wet season) in Dianchi. Moreover, according to the F-IBI assessment system, 25% of the sampling sites were defined as "fine" or above, and 75% were "impaired" or below. This study provided insights on the ecological restoration and precise management of Dianchi Lake basin.

Colleen Linn[1], Lucero Radonic[2] and Mark Axelrod[3], [1]Wayne State University, [2]Northern Arizona University, [3]Michigan State University. **How do different stakeholder groups approach solutions about PFAS contamination in Michigan?**

Qualitative interviews (n=15) were conducted with a diverse group of stakeholders to understand working on per- and polyfluoroalkyl (PFAS) contamination related topics in the state of Michigan. The study aimed to explore how different cultural, social, and geographic factors influence stakeholders' ideas about managing contamination. Stakeholders interviewed include academic, private industry, non-profit, federal agency, tribal governance, and state government representatives. The interviews were analyzed using MaxQDA software to identify themes and compare responses between stakeholder groups. Findings suggest that while stakeholders agree addressing PFAS contamination in sites that impact drinking water should be a top priority, there are differences in how stakeholders perceive the problem of PFAS in the long term. The uncertainty surrounding PFAS contamination and toxicity research, as well as environmental remediation and policy response coordination, influences how stakeholders approach the problem. In conclusion, our research aims to explore the various considerations that stakeholders involved with PFAS should consider when crafting research agendas, approaching policy solutions, and working with communities that are currently impacted by PFAS pollution.

Shai Lis, Aman Basu, Joshua Culpepper and Sapna Sharma, York University. **Exploring the impacts of watershed land cover on spatial heterogeneity in lake ice phenology patterns.**

Lakes in the Northern Hemisphere are losing 17 days of ice cover per century, threatening lake ecosystems, in addition to economic and cultural activities. However, trends in ice loss are spatially heterogeneous across a landscape owing to variations in local climate and lake morphology. Human alterations to individual lake watersheds such as urban heat island effects and deforestation can further influence the timing of ice cover. For example, deforestation increases local air temperatures, wind speeds, and evaporation effects, whereas urban heat islands increase local air temperatures. Both factors are associated with later ice-on and earlier ice-off dates. Current research has yet to quantify the relationship between deforestation, urbanization, and lake ice phenology. Preliminary investigation of six lakes in Vilas, Bayfield, Polk, Douglas and Washburn counties, Wisconsin for a 30-year period between 1989-2022 showed a declining trend in ice-off dates (1.2 days per year earlier) and ice duration (0.3 fewer days per year); however, ice-on timing did not have a significant trend. Forest cover, based on Normalized Density Vegetation Index (NDVI) values,

was not significantly associated with trends in ice phenology. Contrary to expectations, these findings suggest that forest cover does not play a discernable role in changing ice phenology. Further research incorporating additional lakes, industrialization, climate, and lake morphology will help us to understand the roles of forest cover and industrialization in influencing spatially heterogeneous lake ice phenology patterns.

Xiaofeng Liu[1], Runzi Wang[1], Gang Zhao[2], Anna Apostel[3] and Margaret Kalcic[3], [1]School for Environment and Sustainability, University of Michigan, [2]Institute of Geographic Sciences and Natural Resources Research, CAS, [3]Department of Biological Systems Engineering, University of Wisconsin-Madison. **Attributing Historical Nutrient Variations to Climate and Agricultural Practices Changes in the Maumee River Watershed.**

Harmful Algal Blooms in the western Lake Erie, predominantly driven by excessive nutrient (P and N) accumulation from the Maumee River watershed (MRW), have been of great concern due to their far-reaching ecological and socioeconomic implications. Many watershed models have been developed for the MRW to assess the impacts of agricultural practices on nutrient dynamics and project nutrient loadings under future climate change. However, a comprehensive analysis that explicitly estimate attributable contributions to historical nutrient variations due to climate change (particularly driven by anthropogenic carbon emissions) and agricultural practices alterations has been lacking. In this study, we developed the MRW baseline model using completely restructured Soil and Water Assessment Tool (SWAT+) with actual climate observations and spatial refined agricultural practices data from 1989 to 2021. We then simulated the nutrient variations attributable to specific management practices by maintaining these practices at their 1989 levels. To facilitate the simulation of nutrient changes influenced by single anthropogenic forcing, we generated meteorological variables using the quantile mapping method based on the Detection and Attribution Model Intercomparison Project (DAMIP), a component of CMIP6. Finally, the Optimal Fingerprinting method was used to estimate the contributions of each driving factor on the changes in nutrient. This study aims to unravel the complex interplay between climate change, agricultural practices, and nutrient dynamics, informing targeted strategies to address the persisting challenge of HABs in Lake Erie.

John Livernois[1], Ben Blachly[2], John Bratton[3], Maura Flight[2], Rajendra Poudel[4] and Samir Qadir[5], [1]University of Guelph, [2]Industrial Economics, [3]LimnoTech, [4]International Joint Commission, [5]Potomac-Hudson. **Developing an ecosystem valuation plan for the Great Lakes.**

The Great Lakes support a vibrant regional economy and provide valuable ecosystem services to the citizens of Canada and the United States. The values of ecosystem services with established commercial markets such as commercial fishing, tourism, and agriculture are well understood. However, the value of non-market ecosystem services such as biodiversity, nutrient and carbon sequestration, and wildlife habitat, are not well understood and not easily quantified. As a result, they may be overlooked in traditional benefit-cost decision frameworks, risking ineffective, inefficient, or biased resource management and policy development. There is a growing awareness of the need to better understand, measure, and communicate non-market ecosystem values to support management decisions that lead to improved water quality and help meet the goals of the Great Lakes Water Quality Agreement. Currently, however, our understanding of the value of Great Lakes ecosystem services is very limited; indeed, only a handful of primary valuation studies exist for the Great Lakes. The goal of this project was to begin the process of filling the gap in valuation data by determining where the needs for valuation data are greatest and to recommend the highest-

priority options for undertaking Great Lakes ecosystem services valuation exercises over the next decade in support of the IJC Science Plan.

Mallory Llewellyn[1], Emily Griffin[1], Rachel Caspar[1], John Bowden[1], Carol Miller[2], Bridget Baker[1] and Tracie Baker[1, 2], [1]University of Florida, [2]Wayne State University. **Novel Identification and Quantification of Per- and polyfluoroalkyl substances (PFAS) Contamination in a Great Lakes Urban-Dominated Watershed.**

Per- and polyfluoroalkyl substances (PFAS) are a large group of synthetic organic fluoro-compounds that are oil-, water-, and flame-resistant, making them useful in a wide range of commercial and consumer products, as well as resistant to environmental degradation. To assess the impact of urbanization and wastewater treatment processes, surface water and sediment samples were collected at 27 sites within the Great Lakes in the Lake Huron to Lake Erie corridor (HEC), an international waterway including the highly urbanized Detroit and Rouge Rivers, for PFAS investigation using a novel LC-MS/MS method that allowed for simultaneous quantitative analysis of 92 PFAS. Our previous data in the HEC found the highest amount of PFAS contamination at the Rouge River mouth. In addition to evaluating the input of the Rouge River into the HEC, we also evaluated transport of PFAS into the HEC from other major tributaries. Perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) were detected at concentrations above the US EPA's recommended lifetime interim updated health advisories. Surface water samples contained more perfluorohexanoic acid (PFHxA) than any other congener. Several novel congeners, notably 3-Perfluoropentyl propanoic acid (FPePA), were quantified in sediment. The Rouge River and other tributaries contribute significantly to PFAS burden in the HEC including Lake Erie. Overall, our results indicate the need for expanding toxicological research and risk assessment focused on congeners such as PFHxA and PFAS mixtures.

Brent Lofgren, **What Makes Climate Tick? They Forgot About the Sun and No One Noticed.**

Projection of conditions under a climate regime that is unprecedented within the instrumental record necessarily relies to the greatest extent possible on theoretical physics. Namely, spectroscopy, thermodynamics, and fluid dynamics are the main tools at our disposal for looking ahead to warmer conditions that are expected but still technically hypothetical. Such heavy reliance on theory is not within engineers' wheelhouse, nor is healthy skepticism about claims regarding hypothetical conditions. Unfortunately, the Great Lakes hydrological community, starting in 1989 and for decades after, fell into the trap of taking dumbed-down science, in the form of the proposition that air temperature is the singular driver of evapotranspiration, as if it were actual science that remains valid under all conditions. This assumption is a conflation of correlation and causation, with air temperature being a minor factor in direct causation of evapotranspiration, while the main cause of their high correlation is that both are caused by incident sunlight. The overall model was so confusing that people felt no choice but to trust the word of a single person. The insular nature of the Great Lakes hydrological community, a lack of healthy skepticism, the reputation of this methodology being generated by the people who most benefited from its positive reputation, and a reward system based on dramatic results generating interest among the media and the bureaucratic apparatus all contributed to its popularity and longevity.

El Lower, Michigan Sea Grant. **Inclusive Language in AIS Communication - A Workshop Report.**

In partnership with NAISMA and National Invasive Species Awareness Week in February 2023, we will be hosting a National Sea Grant Office grant-funded workshop in Washington, DC, that brings together experts on aquatic invasive species to discuss inclusive language and species naming conventions in our field. This presentation will focus on the proceedings of that workshop, and will highlight the results of discussion on how researchers and agencies can work together on topics such as changing species names that carry xenophobic or otherwise harmful legacies, replacing nationalistic or military metaphors with customized narratives that more accurately describe environmental phenomena, and how to support researchers and organizations who are openly involved in DEIJA work in the face of potential political backlash towards diversity and inclusion efforts. This presentation will provide an opportunity to share new tools, frameworks, and insights collaboratively developed by workshop participants with a broader audience of environmental scientists, managers, and practitioners.

Jarrod Ludwig[1], Megan Belore[2], Emma Bloomfield[3], Andy Cook[2], Mike Diefenbach[4], Angel Guerrero[5], Tim Johnson[3], Tom MacDougall[2], Erik Olsen[6], Joseph D. Schmitt[7], Jason Smith[8] and Jacques Rinchard[1], [1]SUNY Brockport, [2]Ontario Ministry of Natural Resources and Forestry - Lake Erie Management Unit, [3]Ontario Ministry of Natural Resources and Forestry - Glenora Fisheries Station, [4]Northern Michigan University, [5]Little Traverse Bay Bands of Odawa Indians, [6]Grand Traverse Band - Natural Resources Department, [7]United States Geological Survey - Lake Erie Biological Station, [8]Bay Mills Indian Community. **A potential threat to lake whitefish recovery: evaluation of thiamine deficiency.**

In the Great Lakes, lake whitefish hold tremendous ecological, commercial, and cultural value. Not only do they link nearshore and offshore food webs, but also have provided substantial benefits to Indigenous communities and the commercial fishery for centuries. Lake whitefish populations have declined markedly in lakes Michigan, Huron, Erie, and Ontario. *Diporeia*, a major prey for juvenile and adult lake whitefish, has declined in all lakes but Superior, coincident with the establishment of dreissenid mussels. Distribution and diet of lake whitefish have shifted in response to the changing abundance of prey, potentially consuming more dreissenid mussels. Dreissenid mussels contain thiaminase, an enzyme which degrades the essential vitamin thiamine. Fish consuming thiaminase-containing prey may produce thiamine deficient eggs, which can cause improper embryonic development, ultimately decreasing natural recruitment. The goal of this study was to evaluate lake whitefish egg thiamine concentrations across the Great Lakes. Lake whitefish eggs were collected in fall 2023 from lakes Superior, Michigan, Huron, Erie, and Ontario. Egg thiamine concentrations were measured using high performance liquid chromatography. These results will contribute to understanding thiamine deficiency in the Great Lakes, lake whitefish response to ecological change, and address research needs to conserve and restore native lake whitefish.

Gabriella Lükő[1, 2], Eric J Anderson[1], David M Wright[3], Lauren M Fry[3] and Péter Torma[2, 4], [1]Civil & Environmental Engineering, Colorado School of Mines, [2]National Laboratory for Water Science and Water Security, Department of Hydraulic and Water Resources Engineering, Faculty of Civil Engineering, Budapest University of Technology and Economics, [3]National Oceanic and Atmospheric Administration, Great Lakes Environmental Research Laboratory, [4]HUN-REN-SZTE Research Group for Photoacoustic Monitoring of Environmental Processes. **Surface heat fluxes during fractional ice cover over the Great Lakes.**

Turbulent surface heat fluxes play a crucial role in many physical processes of lakes by determining their energy and water budget. Operational hydrodynamic and ice forecasting models have been developed for the Great Lakes; however, modeled turbulent heat fluxes have been only evaluated against ice-free summer observations. Modeled ice concentrations and thicknesses have also been assessed against measurements but without directly testing heat flux estimations, despite the many years of available eddy-covariance (EC) measurements over the Great Lakes. Currently, we use a continuum ice model, focusing on how the model represents fluxes during fractional ice cover. The current ice and open-water flux calculation methods may need to be reviewed. The FVCOM-CICE model was applied for Lake Michigan-Huron to simulate open-water heat fluxes using the COARE algorithm, ice concentrations, and hydrodynamics. First, we check how each model works separately. Open-water sensible and latent heat fluxes are compared with EC measurements for ice-free periods. Ice concentrations are evaluated against satellite-based data at EC tower locations and on lake averages as well. We investigate how modeled fluxes match EC observations during fractional ice cover and explore the possible causes of deviances and errors in the FVCOM-CICE model. Finally, we test new ice and open-water flux calculation methods.

Abigail J. Lynch, USGS National Climate Adaptation Science Center. **Taylor-isms: the Wit and Witisms of Professor William W. Taylor.**

"It is not the critic who counts; not the man who points out how the strong man stumbles, or where the doer of deeds could have done them better. The credit belongs to the man who is actually in the arena..." - President Theodore Roosevelt. This presentation will celebrate Professor William W. Taylor, that "strong man" and "doer of deeds...who is actually in the arena" through sharing a series of Taylor-isms, or phrases commonly used by and typifying Bill Taylor's approach to research, mentorship, and his general outlook on life. Join us for this celebration of Bill's illustrious, innovative, and impactful career.

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Lwabanya Mabo[1], Kelvin N Mukuka[1], Lloyd H. Haambiya[2] and Robert Haloba[3], [1]Lake Tanganyika Research Unit, Department of Fisheries, [2]Frankfurt Zoological Society, Nsumbu-Tanganyika Conservation Program, [3]Lake Tanganyika Development Project. **Growth performance of unimproved *Oreochromis tanganicae* (Gunther, 1894) under community-managed cages southern of Lake Tanganyika.**

The drastic decline in commercial fish catches and stocks on the Lake Tanganyika is forcing riparian communities to seek integrated livelihoods for daily sustenance. Pisciculture development has lately been identified as one aspect to combat rural animal protein deficit, income generation and on the other hand as restorative measure for dwindling natural fish stocks. Conversely, the need to protect the integrity of Great Lakes' ecosystems from introduction of alien and invasive species by using native and endemic species for pisciculture has taken a centre stage in conservation debates. In this study, we investigated the growth performance of an unimproved *Oreochromis tanganicae* (F1) in community-managed cages. The fish was cultured for 210days in ten floating cages installed in two localities of Mpulungu and Nsama districts; attaining average body weight of 260g, 1.72 to 2.45% specific growth rate (SGRs), 1.2 to 1.3g/day of absolute growth rate (AGR) and 2 to 4 kg/m^3 as average fish yield. The feed conversion ratio (FRC) ranged between 4.91 - 8.02. We conclude that with proper and consistent cage management, improved seed quality and training of communities in sustainable aquaculture practices, it is possible to use *O. tanganicae* as candidate species for pisciculture on Lake Tanganyika. Further, improved delivery of extension services, coupled with

genetic improvement of *O. tanganicae* are recommended to augment community participation and adoption of cage pisciculture in livelihood integration and income generation.

Zira MacFarlane and Shannon McCauley, University of Toronto Mississauga. **Storm-Water Retention & Habitat: Impacts of Elevated Salinity on Pond Dwelling Amphibians.**

Urban development has significantly reduced aquatic habitat in the Great Lakes Basin. While efforts are being made to protect and restore remaining waterbodies and wetlands, urban freshwater habitat is limited in area and subject to severe disturbance regimes. This has opened many conversations about conserving aquatic biodiversity in urban areas, with constructed waterbodies such as stormwater management ponds having been suggested to act as habitat for many species. However, due to the engineered purpose of these ponds being to collect urban runoff, the habitat that they provide has much higher salinity (alongside elevated concentrations of other pollutants) than neighboring aquatic habitat. I have established a long-term project to delve into the impacts of elevated salinity in freshwater ponds on amphibian habitat choice, breeding success, and larval development at the community level. This project uses a network of ten previously established experimental ponds in the Koffler Scientific Reserve. In June 2023, we elevated salinity in 5 ponds to Canada's chronic pollution threshold. We have monitored water quality and amphibian larval communities over the summer, looking at larval density, species composition, and body size. We also monitored adult behavior, using visual and acoustic surveys to record pond use patterns. Through this research, we hope to further knowledge about amphibian conservation and the role of stormwater management ponds as urban freshwater habitat.

Paul MacKeigan, Lisa Pérusse, Lisa Tulen and Thierry Mezzana, Environment and Climate Change Canada. **Responding to oil spills in urban waterways: A case study from the National Environmental Emergencies Centre.**

Oil spills have long been considered significant threats to aquatic ecosystems, having severe ecological, economic, and societal consequences. On August 11th, 2023, an industrial fire in a chemical facility in Etobicoke, ON impacted two urban stormwater streams. An unknown quantity of hydrocarbons, flammable solvents, lubricants, and other substances were released to the nearby Mimico and Humber Creeks, in part due to the high volume of water used to extinguish the fire. Thick foam and oil sheen covered the surface along several sections of the creeks, with product spreading to the outlet of Lake Ontario. Significant impacts to wildlife were observed, as more than a hundred oiled birds were captured for rehabilitation, along with thousands of dead fish. Key response activities endured several months and brought together experts, researchers, and industry from various disciplines. These activities included containment and cleanup methods, chemical analyses into the fate and behavior of the product, wildlife monitoring, and shoreline cleanup assessment techniques. This case study provides an understanding of the multifaceted challenges posed by oil spills in urban aquatic ecosystems, as well as the best practices for effective cleanup strategies. Overall, it highlights that our ability to contain and remediate spills requires multidisciplinary approaches that target the total environment, including water, sediment, and wildlife. Additionally, it underlines the role of public awareness and community engagement, and the importance of collaboration between communities, governments, and industries.

Scudder Mackey, PhD[1], **Ebie Holst**[2], John Bratton, PhD[3], Scott Wade[3] and Amanda Kovach[1], [1]Ohio Department of Natural Resources, [2]Cleveland Water Alliance, [3]LimnoTech. **Oil & Chemical Spill Detection and Response within the Lake Erie Basin.**

The Lake Erie Basin has long been vulnerable to industrial hazards due to regional hydrocarbon extraction, an enduring legacy of manufacturing in coastal communities, hosting the first US ports from the Great Lakes St. Lawrence Seaway, and extensive industrial transport activities for industries across the Midwest region. In light of oil spill concerns as well as recent events such as the East Palestine, Ohio chemical spill in 2023, mapping of spill risks needs to be updated to include hydrocarbon as well as chemical-contamination profiles, with a lens for potential impacts on natural, recreational, demographic and economic interests. These insights in turn will help to drive the deployment of new early warning system sensor networks that leverage the recent build-out of a world-class telemetry backbone over the Lake Erie Basin, and provide real-time data access to local, state, and/or federal first-responding agencies. Building upon the risk-mapping efforts of NOAA and other agencies along with inputs from first responders and high-risk organizations in the region, a partnership between the Ohio Department of Natural Resources, Cleveland Water Alliance and LimnoTech is assessing GIS-based oil- and chemical-spill risks, profiling sensor-network monitoring opportunities, and creating data-streaming strategies to support early warning and disaster-response efforts along the Lake Erie coastline that can serve as a pilot for response across the Great Lakes Basin, and for water bodies all over the world.

Michael Mahon[1], Ryan Lepak[1] and Summer Streets[2], [1]US Environmental Protection Agency, [2]MN Pollution Control Agency. **PFAS in Fish in the Minnesota Portion of the Lake Superior Basin.**

Per- and polyfluoroalkyl substances (PFAS) are a human health risk, and fish are a dietary source of PFAS. An analysis of fish from Minnesota, a ceded territory, and reservation waters within the Lake Superior Basin was conducted to provide a better understanding of PFAS contamination. Over 500 fish, including Lake Superior smelt (*Osmerus mordax*), were analyzed for PFAS. Stable isotope ratios were also analyzed to provide better understanding of bioaccumulation and/or biomagnification patterns. Fish from 4 sites were highly impacted by aqueous film forming foam (AFFF) and, simultaneously, had high levels of Perfluorooctane sulfonic acid (PFOS) concentrations (>10 ng g^{-1} WW), while fish from 15 waters had no PFAS detected above the reporting limit. Across inland ecosystems and Lake Superior, stable isotope values indicated higher PFOS concentrations in fish with higher $\delta^{13}C$ values, suggesting that fish with nearshore or benthic habitat preference may be exposed to more PFOS contamination. PFOS concentrations were higher in fish with higher $\delta^{15}N$ values, an isotope system indicative of trophic position, which likely indicates biomagnification of PFOS. Alternatively, $\delta^{15}N$ signal could indicate that habitats of differing $\delta^{15}N$ baselines lend to dissimilar PFOS exposures. Our results indicate a limited occurrence of high PFAS contamination (<10% of sites with >10 ng g^{-1} WW) among the tested water bodies within the Minnesota-Lake Superior basin with clear AFFF signatures present in PFAS profiles at highly contaminated sites.

Juliane Mai[1], Hongren Shen[1], Bryan Tolson[1] and Étienne Gaborit[2], [1]University of Waterloo, [2]Environment and Climate Change Canada. **The Great Lakes Runoff Intercomparison Project (GRIP-GL).**

Model intercomparison studies are carried out to test and compare the simulated outputs of various model setups over the same study domain. The Great Lakes region is such a domain of high public interest as it not only resembles a challenging region to model with its trans-boundary location, strong lake effects, and regions of strong human impact but is also one of the most densely populated areas in the United States and Canada. This study brought together a wide range of

researchers setting up their models of choice in a highly standardized experimental setup using the same geophysical datasets, forcings, common routing product, and locations of performance evaluation across the 1 million km^2 study domain. The study comprises 13 models covering a wide range of model types from Machine Learning based, basin-wise, subbasin-based, and gridded models that are either locally or globally calibrated or calibrated for one of each of six predefined regions of the watershed. This study not only compares models regarding their capability to simulate streamflow (Q) but also evaluates the quality of simulated actual evapotranspiration (AET), surface soil moisture (SSM), and snow water equivalent (SWE). A plenitude of results was derived through this intercomparison and will be presented here. The work is published under https://doi.org/10.5194/hess-26-3537-2022.

Lawrence Makasa, Harris Phiri, Lloyd Haambiya and Danny Sinyinza, Department of Fisheries.
Fluctuation of Water Levels in the Southern Part of Lake Tanganyika, Mpulungu, Zambia, From 1960 to 2021 and its Impact on Lake Tanganyika Fishery and its Catchment.

The water level of Lake Tanganyika Southern end between 1960 and 1964 rose by 2.6m, then dropped by 2.5m up to 1984. Then it roses in 2021 almost same level of 1964. This may have impact to Fisheries poverty reduction or increase, and food security. The activities in the catchment area and increase in population, Agricultural effluent and recreational activities, may contributed to deforestation of watersheds. The changes in some weather parameter (air temperature, water temperature and rainfall) may cause water level variation. The water temperature data shows that there is slightly rise in water temperature at 100m depth. While rainfall data also shows some fluctuation in the amount of rainfall. The fluctuations of water level had also contributed to the depletion of some breeding areas of fish species in the past years, for instance *oreochromis tanganyicae* where it used to breed, people used them as rice field when the level dropped, and rocky fish species were displaced. This resulted to fish species move to suitable place for breeding and also to hiding. As water level started raising in 2019, the fields which were used as rice field were flooded with water and the fish migrated back to its original breeding places, and affected most of the house and some infrastructure which are built near the lake shore.

Olesia Makhutova (Kormilets)[1], Knut Mehler[1], Allison Hrycik[2], Lyubov Burlakova[1] and Alexander Karatayev[1], [1]Great Lakes Center, Buffalo State University, [2]Darrin Freshwater Institute, Rensselaer Polytechnic Institute.
***Dreissena* spp. coverage: a tool for rapid assessment of mussel distribution and condition in the Great Lakes.**

Invasive dreissenid bivalves are considered the most aggressive invaders in freshwaters and have become the major ecosystem engineers in the Great Lakes. Using the Benthic Imaging System, we calculated the percentage of bottom area covered with *Dreissena* in lakes Ontario, Huron, Michigan, and Erie. In all lakes, the highest *Dreissena* coverage was found in the mid-depths (> 30 - 50 and > 50 - 90 m), while the lowest coverage was found in the shallow zone, except in Lake Ontario where the lowest coverage was found in the deepest zone (> 90 m). The most intensive colonization of lake bottom by *Dreissena* occurred in lakes Michigan (38.4%) and Ontario (23.6%), followed by lakes Huron (14.1%) and Erie (8.5%). The correlation between *Dreissena* density and coverage was significant and high (Spearman R: 0.80-0.97) in all lakes. At some depths, however, the results contradicted. Thus, the ratios of *Dreissena* density at > 90 m and ≤ 30 m were 1.8 to 3.9 times higher than the ratios of *Dreissena* coverage between the same depths. This contradiction could potentially be explained by the different sizes of *Dreissena* across depth zones. Indeed, the proportions of large mussels in the shallow zone in lakes Huron and Michigan were higher than in

the deep zone. Thus, coverage provides additional valuable information about the size structure and condition of *Dreissena* in the Great Lakes.

Lamisa Malik[1], Kimberly J. Van Meter[2] and Nandita B. Basu[1, 3], [1]Civil and Environmental Engineering, University of Waterloo, [2]Department of Geography, Pennsylvania State University, PA, [3]Department of Earth and Environmental Sciences, University of Waterloo, ON, Canada.
Phosphorus Legacies: Impact of Past Land Use Practices on Today's Water Quality in the Lake Erie Basin.

Excess phosphorus (P) is one of the key drivers of eutrophication in freshwater bodies globally, including the Lake Erie basin. Although previous efforts effectively reduced point-source P loadings in the lake and mitigated eutrophication in the 1980s, the reoccurrence of blooms is now prevalent. This re-eutrophication is attributed to pollution from non-point sources, such as excess application of manure and P fertilizer that have accumulated over decades as legacy P in the landscape. Efficient management to improve water quality requires quantifying these legacy stores across the basin. We developed a process-based model, ELEMeNT-P, that captures the historical accumulation and depletion of legacy P along the land-aquatic continuum. Utilizing a trajectory of P inputs and outputs spanning over 80 years, we found that since 1930, the Lake Erie basin acted as net P sink. Our results indicate a median accumulation of over 200 kg/ha of P, with 57% in soils, 5% in landfills and 7% in reservoirs and riparian areas. Future simulations suggest that a 40% reduction in P load to Lake Erie is possible only under aggressive management scenarios.

Gurpreet Mangat, Canada Water Agency. **Lakewide Management: Navigating the Great Lakes Ecosystem, One Lake at a Time.**

Lakewide Management under the Great Lakes Water Quality Agreement employs an ecosystem-based approach to address environmental stressors impacting the Great Lakes at the lakewide scale. The Agreement recognizes that each Great Lake has unique ecological characteristics and stressors which must be considered in developing restoration and protection plans. The Lakewide Management process aims to answer three primary questions about each lake: how is the lake doing?; what is stressing the lake?; and what additional actions are necessary? By synthesizing environmental data from diverse scientific disciplines, Lakewide Management gauges the ecosystem status of each lake, informing the development of multi-agency strategies for science-driven management actions. Progress and challenges are tracked, and future research and monitoring priorities are identified. The process is fortified by strong multi-jurisdictional collaboration that engages federal, state and provincial governments, tribal governments, First Nations, Métis, municipal governments, watershed management agencies, and the public. This poster will provide the history and context for Lakewide Management and will detail its key components: Lake Partnerships, Lakewide Action and Management Plans, annual reporting, and identification of science and monitoring priorities.

Nathan Manning, Laura Johnson and Colleen Cosgrove, Heidelberg University NCWQR. **Long Term Hysteresis Patterns in Sediment and Nutrient Concentrations in the Maumee River.**

Sediment, Phosphorus (TP and SRP) and Nitrogen (Nitrate+Nitrite and TN) contributions from the Maumee River are important factors in the overall health of Lake Erie. Due to the relatively low flashiness of the Maumee River, meaningful patterns in storm driven flow-nutrient concentration relationships and their resulting hysteresis patterns can be quantified using, at most, a 3x-per-day sampling regime. The Heidelberg Tributary Loading Program (HTLP), with fifty years of daily/ sub-daily measurements, provides an excellent resource for examining the long term effects of

landscape and in-channel alterations and allows for the quantification of changes in hysteresis patterns at seasonal, annual and decadal time scales. These patterns can reveal both the bed-load contribution to river loads, as well as differences in surface and sub-surface flow paths during and after storm events. Changes in the patterns of hysteresis (clockwise, counter-clockwise and complex) at the multi-annual and seasonal time scale are evident across the period of record, indicating changes in land use, storm frequency and river substrate that have implications for both the timing of the river load and concentrations of these parameters observed in Lake Erie. By understanding how these patterns have varied over time, it may be possible to better calibrate concentration-discharge models for this system, and better understand the timing of sediment and nutrient inputs and their role in cHABs and dead zones in the lake.

Laura Manns[1], Dustin Hardgrove[2], Katherine Velikaz[3], Margo Bjorkman[4], Chris Brown[5] and Jeffrey Baker[6], [1]Ohio Wetlands Association, [2]Pleasant View Middle School, [3]Ottawa River Elementary, [4]Immaculate Conception School, [5]Glandorf Elementary School, [6]Alpha School. **Integrating Project WET, Water Quality, Wetlands, GIS and H2Ohio into the 7th Grade Curriculum.**

This project was funded through an Ohio EPA OEEF mini grant, F23M-011, and was an expansion of F22M-010, providing an authentic, place-based learning opportunity to over 550 seventh grade students around the state of Ohio. Project WET curriculum guide was used as the base of the module, with additional resources including soil and water conservation district stormwater workshops and Ohio Farm Bureau presentations. Students were introduced to surface water quality issues in Ohio, explored the water quality of their local watershed using the Federal EPA's GIS application, How's My Waterway. As part of the unit, students were specifically asked to list two actions they could individually take to improve their local watershed's water quality. Exposer to efforts underway in Ohio to address surface water quality issues through Governor DeWine's H2Ohio Initiative to include wetland enhancement, restoration and creation occurred. Life science standards were met by studying wetland ecosystems, using both WOW! Wonders of Wetlands curriculum guide and hands-on learning activities as part of a wetland field trip. Each school completed a unique final project, synthesizing what was learned and that was meaningful to their distinct, specific community.

Piatã Marques[1], Edina Illyes[1] and Nicholas Madrak[2], [1]Department of Physical & Environmental Sciences, University of Toronto Scarborough, [2]Department of Biology, University of Toronto Scarborough. **Invaders across the cityscape: does level of urbanization influence the invasive potential of the goldfish?**

Urbanization is a global process that cause profound habitat changes that impose new selective forces for trait change that lead to adaptation. Often, urban invaders have traits markedly different from their non-urban conspecifics. However, how traits can vary within urban areas is poorly known. We use Goldfish, *Carassius auratus*, that have invaded urban ponds in the Greater Toronto Area, Canada, to determine whether condition and reproductive investment, two important traits related to invasive potential, change with urban density (measured as impervious area). We sampled two urban ponds for Goldfish and purchased Goldfish from a local pet store. Individuals` liver (L) and gonads (G) were dissected and dried along with their carcass (C). Individual condition was estimated L/C, and reproductive investment was estimated as G/C. We found that condition and reproductive investment vary among urban pond and pet store Goldfish (ANOVA $p<0.001$). Goldfish in the pond surrounded by less impervious areas had the best condition compared to Goldfish in the with more impervious areas and pet store Goldfish (Tukey pairwise $p<0.001$). Goldfish in the pond with less impervious area had lower reproductive investment than Goldfish in

the pond with high impervious area and from the pet store (Tukey pairwise $p<0.001$). Our results indicates that the trait response of Goldfish to urbanization is context dependent. This suggest that the invasive potential of Goldfish can vary throughout the urban landscape.

Raissa Marques Mendonca[1], Ishfaq Rahman[2] and Lauren Kinsman-Costello[1], [1]Kent State University, [2]University of Toledo. **Tools and workflows of a data management system for heterogeneous wetland monitoring data.**

Data generated by long-term environmental monitoring programs are extremely valuable, but its temporal and geographical extent pose challenges to data management and quality assurance. The H2Ohio Wetland Monitoring Program (WMP) oversees collection of diverse data types by geographically distributed crews in up to 170 unique wetland projects. Many strategies and tools have been tested and implemented within the WMP to ensure data preservation and guarantee scientific rigor while optimizing efficiencies from data collection to dissemination and adopting FAIR principles. We have implemented the use of custom digital surveys to centralize data entry and ensure detailed metadata and field measurement records. Automated workflows have been developed with Python scripts to export and integrate field and laboratory data into GitHub for version control. Our continuous integration system through GitHub Actions routinely performs pre-processing and quality checks on incoming data and builds verified and integrated datasets. Full access of verified data to researchers and stakeholders is still under development, along with refinement and beta testing of our current workflows. Some challenges we are iteratively addressing include: 1) effective data centralization, 2) standardization of data format and processing, 3) thorough documentation and flagging, 3) quality assurance of raw and processed data analyzed using different approaches, 4) secure and findable storage and backup of data of different kinds and scales, and 5) timely data accessibility to researchers and stakeholders.

Christopher Marshall[1], Joseph Connolly[1], Warren Currie[2], Kelly Bowen[2], James Watkins[1] and Lars Rudstam[1], [1]Cornell University, [2]Fisheries and Oceans 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.

Dawn Martin Hill[1, 2], Rohini Patel[3], Hiliary Monteith[1] and Makasa Looking Horse[1, 2], [1]McMaster University, [2]Six Nations, [3]University of Toronto. **Kayanní:yo ('a good path'): Working with Indigenous ecological knowledge to advance resiliency.**

For centuries, the Haudenosaunee people have viewed the "law of the land" as a natural law, known as the Great Law of Peace. This law informs their traditions and guides their governance. Water is especially important to the Haudenosaunee as it provides spiritual, ceremonial, social, and practical benefits. However, climate change (CC) and colonialism have caused severe water crises worldwide. Indigenous Knowledge (IK) is increasingly recognized as valuable for building resilience and adapting to environmental change. The Ohneganos team, led by Indigenous scholars, community, and interdisciplinary experts, has developed strategies for water governance that prioritize Indigenous rights, health, and community-led solutions, including monitoring and training youth, water sensors, bilingual VR simulations, and mapping. These strategies combine IK with western science based on three pillars of research: 1) Indigenous Science & Technologies; 2) Climate change impact on Water and sustainability; 3) Youth and Capacity Development. Our aim is to establish a research hub at Six Nations of the Grand River (SN) to address high risk challenges through a Haudenosaunee lens. We will address needs for groundwater mapping & monitoring, and innovations at SN. Indigenous communities must have agency over their own water quality data in the face of CC. The Ohneganos research centre will provide a space to collaborate with all stakeholders including leadership of the Haudenosaunee Confederacy Council and Six Nations Elected Council with sustainable environments as a central mandate.

Jérôme Marty, International Association for Great Lakes Research. **Building a Framework Toward Bridging Traditional Ecological Knowledge and Western Science to Support Decision Making within the Great Lakes.**

In 2021, the International Join Commission (IJC) approved a new project designed to advance knowledge on how Traditional Ecological Knowledge (TEK) can have a meaningful role in the primarily Western science approach to IJC advice, and to develop recommendations on how to develop a framework through which TEK and Western science can collaborate within the IJC's structure within the Great Lakes. The growing interest in understanding the collaboration between TEK and Western science has led to many publications proving recommendations on the ways institutions, governments and people should engage with Indigenous knowledge respectfully. Also, as Tribes, First Nations, Métis, and other Indigenous communities and nations have become increasingly involved in inter-jurisdictional water and resource management, there are increasing public examples of ways in which TEK and Western science have collaborated to help inform management decisions within Indigenous communities, as well as within these inter-jurisdictional regimes. With this presentation, we report on a literature survey as well as on finding from a listening session conducted in Akwesasne. This session highlighted the need to recognize, acknowledge and respect current and past context and realities to develop a trusting relationship between science organizations and community members sharing about their experiences and knowledge. In addition, the session highlighted the importance of using a terminology that is informed by the community (and possibly grounded in the language) for effective bridging of knowledge systems.

Doran Mason[1], Edward Rutherford[1], Hongyan Zhang[2], Brian Brenton[3] and Lori Ivan[4], [1]NOAA Great Lakes Environmental Research Laboratory, [2]Eureka Aquatic Research, LLC, [3]Brenton Consulting, LLC, [4]Michigan State University. **Two and a half decades of food web modeling at NOAA GLERL.**

Analysis of anthropogenic factors (land use, climate change, invasive species) and their effects on Great Lakes food webs have been a mainstay of GLERL science over the past twenty-five years. GLERL scientists, and their many federal, state, provincial and university partners, have developed an ensemble of models to quantify and assess the singular and interactive effects of these stressors on food webs, and to facilitate understanding of their current and potential future effects. The development and implementation of food web models have varied in complexity, and ranged from physiologically-based habitat suitability models, individual-based bioenergetics models of representative aquatic communities, static and dynamic food web models, to a linked model framework. The linked model framework includes outputs from climate and weather model projections of temperature, wind and nutrients, that serve as inputs to a 3-D hydrodynamics model, which in turn drives a whole ecosystem model that includes biogeochemical cycling, food webs, fish harvest and socio-economics. These models have informed invasive species and fisheries management actions, and contributed to public outreach and education through online distribution of food web networks for each Great Lake, and even a publication in National Geographic magazine. Herein, we present the history of development of these models at GLERL and highlight some key results.

Haley Matschke, Rideau Valley Conservation Authority. **Creating community partnerships to support the foundation of water quality monitoring and environmental advocacy.**

Established in the early 2000s, the Rideau Valley Conservation Authority's (RVCA) monitoring programs were designed with community involvement in mind. Originally developed as a community monitoring program, the Watershed Watch (lake monitoring) program aimed to foster community involvement, encourage stewardship, and collect environmental data to gain an understanding of watershed conditions. Now, having been in operation for over 20 years, this program has been able to create a long-term data set and report on water quality conditions, all while developing long-standing partnerships within the community. These partners have been able to ensure data continuity with limited resources, serve as program advocates at the municipal level, and ensure environmental advocacy at the community level. The program's foundation and long-standing reputation have supported the RVCA in its goal of increasing awareness and appreciation for the watershed, engaging in collaboration with the academic community, and fostering partnerships at the municipal, provincial and federal levels. These relationships have allowed for continued engagement of the community and agencies which has resulted in the development of new programs and targeted monitoring efforts, as well as stewardship and restoration projects and initiatives. This presentation will discuss the foundation of RVCA's community partnerships and monitoring programs, along with its success stories and challenges across the watershed.

Robin Mattheus, Mitchell Barklage, Liane Rosario, Andrew Phillips and Steven Brown, Illinois State Geological Survey **High-resolution mapping of lake-bottom geology from grab, core, reflection geophysical, and airborne LiDAR-derived datasets: Insights from the Chicago coast of Lake Michigan.**

The 'white ribbon' is a shoreline-proximal strip of infrequently mapped lake-bottom terrain above the depth-of-closure. Understanding the lake-bottom geologic composition of this highly

dynamic part of the coastal system is important for shoreline management. We classified and mapped distributions of different substrate types along the greater Chicago coast to aid our evolving understanding of sand-distribution patterns across a geologically complex and highly fragmented littoral zone. The continuity of geological map units, parameterized from archival and newly acquired sample information, was traced from 2020 USACE/NOAA LiDAR-based DEMs and model derivatives (i.e., slope/aspect). The bathymetric data were supplemented with ~165 trackline km of 'chirper' seismic reflection data, 1-2 m sediment cores (n = 20), and >200 Ponar-grab samples, all acquired between 2022 and 2023. Data-derivative map products include: (1) A map of lake-bottom geology, and (2) an isopach model of drift-sand thickness. Our data show that drift-sand deposits are: (1) Imaged as a smooth texture in bathymetric DEMs; (2) thickest within urban lakefront embayments (i.e., beaches); (3) predominantly NE-, E-, and/or SE-sloping; (4) occasionally found as thin, isolated, and shoreline-detached sheets; and (5) influenced by antecedent topographic conditions (e.g., of the bedrock surface) and lake-bottom infrastructure. Sand deposits, which showed the most 2008-2020 vertical change (of delineated map units), transition laterally to a more textured lake bottom comprised of E to W-oriented gravel ridges, outcrops of carbonate bedrock, and scoured fine-grained till deposits.

Luke McGill[1], Paris Collingsworth[2], Tomas Höök[2] and Austin Happel[3], [1]Purdue University, [2]Purdue University, Indiana-Illinois Sea Grant, [3]Shedd Aquarium. **Acoustic Tracking of Largemouth Bass in a Busy, Steel-Walled Urban Waterway.**

The Chicago Area Waterway System, or CAWS, has been dredged, channelized, straightened, connected to the city's sewer system, and had its natural flow reversed. Recent efforts to improve habitat conditions and water quality in the CAWS include installing artificial islands and increasing stormwater reservoir capacity. To better understand how largemouth bass move throughout the system and respond to changing environmental conditions, we deployed an acoustic telemetry array and environmental sensors within the CAWS. We found that largemouth bass prefer areas away from the main channel with more complex habitat and shoreline, such as barge slips and turning basins. During periods of heavy rainfall, bass could tolerate low (<2mg/L) oxygen conditions but would seek out other areas when the water became anoxic. In this presentation, we will also discuss how the home range and daily movement vary in response to poor water quality events, habitat differences, and seasonal environmental differences.

Autumn McGowan[1], David Karpovich[2, 3], Bretton Joldersma[4], Rebecca Bowen[2, 3], Craig Stow[5, 6] and **Douglas Pearsall**[1], [1]The Nature Conservancy, [2]Saginaw Valley State University, [3]Saginaw Bay Environmental Science Institute, [4]Michigan Department of Environment, Great Lakes, and Energy, [5]National Oceanic and Atmospheric Administration, [6]NOAA Great Lakes Environmental Research Laboratory. **Sustaining Long-term Adaptive Water Quality Monitoring in Saginaw Bay and the Great Lakes.**

Saginaw Bay (SB) is the largest source of nutrients to Lake Huron, and while management of SB falls to the State of Michigan, the transboundary implications of actions that affect SB nutrient loads necessitate engaging multijurisdictional partners through Annexes 2 (Lakewide Management) and 4 (Nutrients) of the Great Lakes Water Quality Agreement. The Saginaw Bay Monitoring Consortium (SBMC) has initiated a comprehensive water quality monitoring network, funded through GLRI, to support tributary and bay monitoring for three years. However, establishing trends and addressing water quality issues in SB will require long term datasets, greater than three years, and the future of sustainable funding is uncertain. To understand models of governance and sustainable funding and enable the SBMC to continue its mission, including sharing data and

knowledge across the Great Lakes and informing Annexes 2 and 4, we interviewed personnel from various watershed-based water quality monitoring initiatives within and outside the Great Lakes Basin including the US EPA's National Estuary Program, NOAA's National Estuarine Research Reserve System, and US EPA's Geographic Programs which include GLRI. For each program, we assessed the roles and responsibilities of partners, funding stability, and governance structures and then evaluated the applicability of each to SB before presenting our recommendations to the SBMC Advisory Committee. We will present our recommendations and suggest how our findings could inform similar efforts in the Great Lakes.

Matthew McLean, U.S. Fish and Wildlife Service. **Implementing Survey123 and Field Maps for Partner Data Collection.**

In 2019, the aquatic invasive species (AIS) team from the Alpena Fish and Wildlife Conservation Office (FWCO) implemented Survey123 and Field Maps during data collection. After some growing pains, these tools proved to be very beneficial in terms efficiency both in collecting data and performing quality control of the data. In 2020 the Alpena FWCO partnered with the Sault Saint Marie Tribe of Chippewa Indians, Department of Fisheries and Oceans Canada, and the Ontario Ministry of Natural Resources and Forestry to help aid in the collection of AIS early detection and monitoring (EDM) data in the St. Marys River. In 2020 and 2021, partners continued to use paper data sheets that would be given to the Alpena FWCO at the end of each field season. These data sheets would then be entered into Survey123 by Alpena FWCO staff, which was a tedious and sometimes difficult task. In 2022, the Alpena FWCO introduced the idea of getting their partners trained on the use of Survey123 and Field Maps, and once all partners were on board, training commenced. Protocols and other supporting documents were created and stored on a Microsoft SharePoint site, collaborator accounts were made for ArcGIS Online and training sessions were held via Microsoft Teams. Survey123 for partners was successfully launched in 2022, which resulted in time and money saved, fewer data errors, and better communication of results between partners.

Rachel McNamee and Rebecca Rooney, University of Waterloo. **Microplastics accumulation in biofilm.**

Currently, freshwater lakes, including the Great Lakes, are inundated with microplastic pollution. We performed a whole lake microplastic addition experiment at the International Institute for Sustainable Development Experimental Lakes Area (IISD-ELA). Our research goals were to evaluate the fate and effects of microplastic fragments (PE, PS, and PET, sized 10-500 μm) on a whole lake ecosystem. My research investigates rates of microplastic accumulation in the biofilm, and their effect to this community. Biofilms are essential for aquatic habitats because of their contributions to nutrient cycling as a primary producer and as a food source for higher trophic organisms, additionally biofilms are sensitive to environmental stressors and play a role in the fate of contaminants. Terracotta flowerpots were deployed in the early spring for 1 year of baseline and 1 year of additions in the littoral sections of the reference and study lakes. After 8-10 weeks, biofilm was collected and subsampled. We found an increase in the biofilm's biomass (as measured by dry weight and ash-free dry mass), and no effect to the photosynthetic content of the biofilm (as measured by [chlorophyll-a] or [phaeophytin]). Our results suggest that microplastics are accumulating in biofilm and that this is potentially shifting the community growth rates, without having a significant effect on the biofilm photosynthetic abilities.

Brayden McNeill, Graham Stonebridge, Andre Erler, David Hah and Steve Frey, Aquanty.
HGSRT: Connecting streams, lakes, and groundwater in real time and on the web.

HGSRT: real-time hydrologic forecasting driven by fully-integrated, physics-based simulations• Aquanty staff present HydroGeoSphere Real-Time (HGSRT), a digital web application for disseminating near-real-time hydrologic forecasts based on HydroGeoSphere, a fully integrated hydrologic modeling system that simulates the entire terrestrial water cycle. Three-dimensional physics-based models were built using HydroGeoSphere for twelve ~5000 km2 watersheds in Southern Ontario, each draining into the Great Lakes. These models are being run in near-real-time with weather forecast data and IOT sensor data, providing digital twins of the watersheds. With state-of-the-art fully integrated models under the hood, the HGSRT forecasts can confer up-to-date insights into physical processes such as streamflow, groundwater, soil moisture, recharge/discharge, and reservoir conditions. The web application is responsive and allows for water managers to monitor conditions on-the-go, including in ungauged areas. Recent developments and exciting new opportunities will be presented including water quality forecasting, quantifying forecast skill, and the development of a continental scale, open-source data framework to enable HGSRT deployment throughout the Great Lakes basin.

Amelia McReynolds[1], Bernie Pientka[2], Mark Henderson[3], Michael Jech[4], Lars Rudstam[5], Ellen Marsden[1] and Jason Stockwell[1], [1]University of Vermont, [2]Vermont Fish and Wildlife Department, [3]Vermont Cooperative Fish and Wildlife Research Unit, [4]NOAA Northeast Fisheries Science Center, [5]Cornell University. **Shifts in rainbow smelt distributions during alewife invasion in Lake Champlain.**

The adaptability of mid-trophic level fishes to changing environments is critical for food web structure and function, including piscivore production. Alewife (*Alosa pseudoharengus*) and rainbow smelt (*Osmerus mordax*) appear to coexist due to differential use of thermal habitat and prey in areas where they are both native (along the east coast of North America) and non-native (the Laurentian Great Lakes). Lake Champlain provides an interesting case study: rainbow smelt are native and alewife invaded circa 2003. We used acoustic and trawl data from 1990 to 2015 to determine how rainbow smelt responded to alewife across three environmentally distinct basins. Rainbow smelt can shift habitat selection to deeper, colder water apparently to avoid competition with alewife for near-surface planktonic food. In shallow basins of Lake Champlain, however, hypoxia may limit the volume of acceptable rainbow smelt habitat, increasing spatio-temporal overlap across cohorts and consequent cannibalism and population declines of rainbow smelt. We used spatially extensive acoustic data, paired with temperature and oxygen profiles taken during the acoustic-trawl survey, to conduct detailed analyses of vertical distributions. After alewife invasion, young-of-the-year rainbow smelt shifted deeper in the water column and overlapped with yearling-and-older conspecifics in the two shallow basins, but not in the deep basin of the lake. This work helps to better understand changing food web interactions in large lakes resulting from species invasions and environmental change, including increasing hypoxia.

Jay Meldrum, Michigan Technological University. **Undergraduate Research in Alternative and Renewable Energy Systems.**

The cost of electricity in the Keweenaw Peninsula of Michigan is nearly the highest in the US. This prompted the creation of the Alternative Energy Enterprise Class to educate and inform the community on ways to reduce their energy using renewables and more efficient heating and cooling systems. Students from freshman to graduate students can enroll and stay in the class for more than one semester. An archival semester report is expected so that new students can take a

topic further along learning from their predecessors. Topics include solar sun trackers, geothermal heating and cooling using water from an abandoned mine shaft, solar with battery backup in a Sustainability Demonstration House, an award winning Community Solar project in a neighboring city, Pumped Underground Storage Hydro (PUSH) using abandoned mine shaft water, the creation of a Regional Test Center for testing solar in extreme snow conditions, and consulting with an Island Community on how they can incorporate more renewables to reduce their carbon footprint. The electrification of recreational boats can also help reduce our carbon footprint and is another project currently being researched. Educating our young professionals in these technologies while informing the public of their viability is one path in attaining our energy targets. This presentation will show how Michigan Tech is contributing to a greener society.

W. Robert Midden[1], Corbin Kohart[1], Genna Hunt[1], Lucinda Busselle[1] and Lauren Kinsman-Costello[2], [1]Bowling Green State University, [2]Kent State University. **Evaluation of phosphorus and nitrogen export reduction by construction of geographically isolated wetlands.**

Geographically isolated wetlands (GIWs) are maintained, restored, and created to realize several benefits including increased wildlife habitat diversity, flood reduction, and retention of phosphorus (P) and nitrogen (N) so as to reduce downstream eutrophication. A number of studies of the hydrologic connectivity of GIWs and their effects on downstream flow in the surrounding watershed have been reported but the effects of GIWs on phosphorus and nitrogen transport have not been comprehensively evaluated. By definition, GIWs are surrounded by uplands with no discrete inflows or outflows that deliver P and N input. However, restored and constructed GIWs often replace land uses, such as agriculture, that can export substantive P and N loads. Decisions about whether to convert other land uses to GIWs sometimes depend on the estimate of potential benefit in terms of reduction of P and N export. We will summarize a method for estimating the reduction of P and N export due to conversion of agricultural land to GIWs using a recently created 45 hectare wetlands site with 38 GIWs ranging in size from 0.04 to 1.2 hectares, as an example of how this type of estimate can be generated. Ideal estimation requires pre-construction data, but we will show how edge-of-field studies, rainfall data, and evaluation of undisturbed soils and site design can be used to generate an estimate of significant value for land management decisions.

Nicole Turner, Melanie Croft White, Christine Boston and **Jon Midwood**, Fisheries and Oceans Canada. **Spatio-temporal comparison of nearshore fish communities in Hamilton Harbour and Bay of Quinte AOCs.**

Nearshore areas in Lake Ontario have changed considerably due to anthropogenic disturbance, which led to areas like Hamilton Harbour (HH) being designated as Areas of Concern (AOC). As conditions within the Lake continue to change over time, it is essential to incorporate these trends when assessing the status of an AOC. Here we assess spatial and temporal changes in HH fish populations using fish community metrics (e.g., Index of Biotic Integrity [IBI]), species occurrence, and catch models. We compare patterns to the Bay of Quinte AOC (BoQ), a similar sheltered embayment where the condition of the fish populations is no longer deemed impaired. There were clear spatial differences within HH and limited evidence for improvement in nearshore fish populations with the exception of a decline in non-native species catch and richness and total offshore species catch. Similar declines in non-native species richness were evident in the BoQ, but IBI and associated metrics including proportion of piscivore biomass and native species catch and richness were greater in the BoQ while the condition of fish populations was also relatively stable. In contrast, several metrics and species in HH showed recent declines that rolled back improvements observed in the early 2000s. Such HH AOC-specific changes suggest that local (e.g., anthropogenic

disturbance, novel invasive species, and minimal changes in habitat supply) rather than regional factors are limiting recovery of the fish community.

Ajode Z, Migeni and Ted Lawrence, African Center for Aquatic Research and Education.
Advisory Groups: A Sustainable Framework for Strengthening Collaboration and Sound-Management of the African Great Lakes Resources.

Harboring over 28% of the world's frozen freshwater, the African Great Lakes, which comprises of: Edward and Albert, Kivu, Malawi/Niassa/Nyasa Basin, Tanganyika, Turkana, and Victoria, contains extraordinary geophysical features and associated natural resource and biodiversity values, which are critical to supporting over 62 million livelihoods and have therefore continued experiencing intense threats and pressures from rapidly increasing human populations and accelerating economic growth. These exemplary resources and habitats to millions of animals and human population are rapidly deteriorating from pollution, over extraction of natural resources, agricultural intensification. These lakes, are multijurisdictional shared by two or more of the 10 riparian countries, therefore facilitating complexities and myriad of challenges to their sustainable use, care, and management, and even decision making. To achieve the required level of management and protection, these resources need sustained collaboration, understanding and regular information exchange from both local communities, freshwater experts, governments, and decision-makers. Through the African Center for Aquatic Research and Education, to address the above multi-layer of issues, we have established a highly collaborative network of African Great Lakes freshwater experts through the Advisory Groups program, a successful model that was borrowed from the North American-Great Lakes Fishery Commission. This presentation aims to explore the experiences, lessons learnt, opportunities, specific way-forward and pragmatic solutions for successful implementation of the Advisory Groups Program on the African Great Lakes.

Carol Miller[1], Sydni Jordan[2], Tracie Baker[3], John Norton[4], Andrea Busch[4] and Catherine Willey[4], [1]Wayne State University, [2]HDR Inc., [3]University of Florida, [4]Great Lakes Water Authority. **PFAS Loadings to a Regional Treatment/Recovery Facility Serving Multiple Land Uses and Demographics.**

Per- and polyfluoroalkyl substances (PFAS) are infamous for their persistence as emerging environmental contaminants. Wastewater treatment plants (WWTPs) and Water Resource Recovery Facilities (WRRFs) are a significant point of collection, treatment, and destruction of these contaminants. This presentation documents PFAS loadings to a major facility in the Great Lakes region that collects from combined systems. The relative contributions from stormwater and sanitary sewerage are determined through detailed analysis of both wet weather and dry weather loadings.

Zachary Mills[1], Seth Krebs[1], Leah Kuester[1], Austin Skenandore[1], John Luke[1], Elizabeth Kowalcyzk[1], Diego Ruiz-González[2], Cynthya Maldonado-Mojica[2] and Héctor Hernández[2], [1]University of Wisconsin - Milwaukee, [2]El Colegio de la Frontera Sur. **Understanding variables affecting dwarf red mangroves in a karstic freshwater environment - Bacalar, Mexico.**

Land development and climate change has contributed to a 16% decline in Mexico's mangrove forests. Previous studies on dwarf red mangroves are limited to marine environments, unlike the karstic freshwater environment of Laguna Bacalar, Mexico's second largest lake located in the southern Yucatan. Prop root density and estimates of above-ground biomass were quantified along one to three 50m transects at each of 19 individual sites. Comparisons of mangrove numbers with density of leaf litter, bacterial mats (microbialites), and roots, (including prop root number,

height from ground to highest prop root, height from highest prop root to canopy, length, and width) identified at least two environmental patterns north to south across this ~ 60 km long system. Generally, leaf litter density was greater in the north, proportional with higher tree densities and more standing water. In the south, large submerged bacterial mats appeared to correlate with upward growth of mangroves over outwards growth of prop roots. Stromatolite and microbialite communities are oxygen producing organisms and data suggested potential relationships in mangroves, microbialites, and minerals. Future studies should incorporate interdisciplinary projects involving soil analysis and comparing microorganism diversity and abundance living in conjugation with mangroves to better understand conditions that they thrive in. Being a rare freshwater mangrove environment, contribution towards broadening community perspectives is pivotal when looking at best management practices and stronger, more ethical methods of conservation.

Kristie Mitchell[1], Lyndsie Collis[2], Daniel Peters[2], Jim Hood[2], Reagan Errera[3], Henry Vanderploeg[3] and Subba Rao Chaganti[1], [1]Cooperative Institute for Great Lakes Research, University of Michigan, Ann Arbor, MI, [2]Department of Evolution, Ecology, and Organismal Biology (EEOB), The Ohio State University, Columbus, OH, [3]Great Lakes Environmental Research Laboratory, NOAA, Ann Arbor, MI. **Zooplankton grazing preferences throughout a cyanobacterial bloom season in Western Lake Erie.**

Cyanobacterial harmful algal blooms (cHABs) are a growing concern in freshwater ecosystems worldwide, including Lake Erie. Zooplankton are important for regulating phytoplankton succession and can promote or suppress cHAB formation. In turn, grazer resistance and poor nutritional quality of cyanobacteria can shape zooplankton community structure. However, the understanding of changes in zooplankton-phytoplankton interactions during cHAB periods remains limited, prompting our study to investigate their influence on energy flow in the lower food web. Our research aimed to discern zooplankton-grazing preferences across different stages of cHABs by conducting seven grazing experiments from late June to early October with water and zooplankton collected from Western Lake Erie. Using 16S and 18S rRNA metabarcoding analyses, we identified changes in prey availability and preferences. Results revealed the presence of cyanobacteria, including *Microcystis*, in mesozooplankton gut contents. Interestingly, the relative abundance of cyanobacteria was low and decreased during the peak *Microcystis* bloom. Mesozooplankton exhibited a shift in grazing preferences from diatoms to ciliates, coinciding with the transition from edible diatoms (e.g., *Skeletonema*) to non-edible diatoms (*Aulacoseira*) during the *Microcystis* peak bloom. These findings bear significant implications for food web modeling, offering valuable data to refine and enhance our understanding of lower trophic interactions. Understanding the energy flow through the lower food web in various cHAB environments will help inform decision-making to support and maintain healthy Great Lakes fisheries.

Hamid Mohebzadeh[1], Asim Biswas[2] and Prasad Daggupati[1], [1]School of Engineering, University of Guelph, [2]School of Environmental Sciences, University of Guelph. **Analyzing the effectiveness of best management practices on ephemeral gully erosion using the AnnAGNPS model.**

To reduce the potential danger of soil loss due to ephemeral gullies, it is crucial to adopt Best Management Practices (BMPs) that enhance water quality and prevent damage to land by removing sediments from field runoff. In the current research, Annualized Agricultural Non-Point Source (AnnAGNPS) model was employed to determine the effectiveness of five BMPs for reduction of sheet and rill, as well as ephemeral gully erosion in an agricultural watershed of Kettle Creek Paired Watersheds (KCPWs) in Southern Ontario, Canada. After successful calibration of the model following a sensitivity analysis using a combination of Latin Hypercube Sampling (LHS) and One-

At-a-Time (OAT) approach, the model was utilized to simulate the effectiveness of BMPs in reducing sediment load. According to the BMP simulation, no-till was consistently successful in decreasing sheet and rill erosion in all seasons, with an average reduction of 83%. Similarly, during all seasons, grassed waterways, no-till, and conservation tillage were the most effective BMPs for reducing gully erosion, with an efficiency of 89%, 88%, and 88%, respectively. Additionally, no-till was found to be the most efficient BMP for reducing total sediment load, followed by conservation tillage and grassed waterways, with reduction efficiencies of 88%, 66%, and 55%, respectively. These findings will aid in decision-making when implementing BMPs to decrease sediment load caused by various forms of erosion, such as sheet and rill erosion or ephemeral gully.

Ali Mokdad, University of Windsor. **Plasticity from hatcheries to the wild: insights into the phenotype-environment mismatch.**

Captive-breeding programs tend to produce behaviourally and neurologically compromised animals that deviate from wild phenotypes and are less fit in natural settings. Phenotypic plasticity can play a large role in behavioural deficiencies expressed by captive-reared animals upon release. Understanding the environmental factors and mechanisms that shape the phenotype can help conservation biologists and managers to alter rearing conditions and release protocols of captive-bred animals, destined for stocking, to increase the success of reintroduction efforts. In this talk I will present an overview of some of my collaborative work with fisheries managers to identify the effects of conditioning tactics on fitness-related behaviours in Atlantic Salmon (Salmo salar). Specifically, we investigated the behavioural and neuromorphological effects of manipulating early developmental rearing via enrichment (sensory enrichment and physical enrichment) as well as the effects of transport and release method on post-release behaviour. Here I will present lessons learned from my PhD work to highlight the benefits and difficulties of co-productive and co-innovative work to advance fisheries and conservation studies aimed at reintroduction efforts.

Barbara Moktthewenkwe Wall[1], Mary-Claire Buell[2], **Chris Furgal**[3], **Emma Pirie**[4], **Marsha Serville-Tertullian**[4], **Ruth Duncan**[4], **Jessica Pauze**[4], **Caitlyn Veri**[4] and **Alexander Leyland**[4], [1]Trent University, Chanie Wenjack School for Indigenous Studies, [2]Trent Unversity, School of the Environment/Forensics, [3]Trent University, Chanie Wenjack School for Indigenous Studies and School for the Environment, [4]Trent University. **Maawanji'idiwag: Reflections on the journey of building a multi-national network to support Indigenous-led Great Lakes Research.**

The formative Indigenous Great Lakes Network (IGLN) is an outcome of a three-phased project: "Towards consideration for an Indigenous-directed sister Smart Great Lakes Initiative (SGLI)," led by the Indigenous Environmental Institute at Trent University. Phase 1 focused on identifying the current research and monitoring in Great Lakes Indigenous communities; the interests/priorities of Indigenous Nations/organizations, and their interest in engaging in some form of collective effort such as SGLI. Phase 1 demonstrated that predominantly academic reporting and peer reviewed literature 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/organizations and created a discussion platform focused on research, and data governance challenges. Phase 3 was a highly anticipated in-person gathering of representatives of First Nations, Tribal Nations across the lakes and the Métis Nation of Ontario. Beginning with Ceremony, discussions focused on network priorities and focus, research priorities, funding/resources, and network governance/formation. Discussion groups were led by the project team, assisted by undergraduate student note takers. This session will be introduced by the project co-leads and will include viewing of an artistic video summary of Phase 3, and the next steps in

creation of IGLN. In addition, undergraduate students and potentially community members will reflect insights gained from their participation in the in-person gathering and their hopes for how the IGLN will support future community-lead Great Lakes Research.

Brigitte Mongane, AWIS. **The exploitation of methane gas in Lake Kivu and its potential impact on the socio-economic development of The Democratic Republic of Congo and the African Great Lakes region.**

Lake Kivu is one of the Great Lakes of Africa. It is located on the border of the Democratic Republic of Congo and Rwanda. Lake Kivu contains a high saturation of gases, including methane and carbon dioxide. These gases, of volcanic origin, make Lake Kivu prone to severe limnic eruptions. The methane gas found in Lake Kivu has the potential to generate up to 25MW of electric energy and increase the production and distribution of electricity, which is almost nonexistent in the DRC. This study analyzes the value of methane gas exploitation in Lake Kivu and its potential impact on the socio-economic development of the DRC and the Great Lakes region, as well as the associated risks with the presence and extraction of this gas. The method used was a quantitative analytical approach with hydrological, limnological, biological, physio-chemical, and economic references related to studies already conducted in Lake Kivu. Our results showed that Lake Kivu has a wealth of potential and proven energy resources. The extraction and transformation of methane gas will contribute to the socio-economic growth of that region through the production of electricity, cooking gas, fuel, fertilizers for agriculture, and other industrial and petrochemical uses as well as a potential for eco-tourism. The results also showed that this extraction needs to be done safely, as gas leaks could harm human health and the biodiversity of the region.

Dan Monhollon, United States Geological Survey. **Minimizing double counting of round goby in continuous image sequences gathered by underwater robots.**

Autonomous underwater vehicles (AUVs) are increasingly being used in the Great Lakes to monitor and map ecological features of the lakebed by gathering and interpreting images along photo transects with spatially overlapping imagery. Accurate estimation of invasive round goby (*Neogobius melanostomus*) population densities from AUV imagery requires that double counting of individuals is minimized to avoid inflation of abundance estimates. However, conservative decision rules may lead to missed opportunities to incorporate greater numbers of images and censused individuals in AUV surveys. We sought to quantify the distance at which the probability of double counting an individual round goby approaches zero. We automated detection of individuals using machine learning and calculated the intersection over union (IoU) of round goby bounding boxes in sequential, overlapping image pairs from Lake Michigan in August — September 2020. IoU near 100% and/or differences in abundance estimates near zero indicated little to no change in round goby locations between image pairs. In cases where results suggested greater round goby movement, individual movement trajectories were examined to determine (a) whether round gobies changed locations as they were being imaged, and (b) whether they were being double counted across sequential frames. Our findings allow us to increase the sample size, and therefore, the precision of round goby population density estimates across the Great Lakes while also inferring round goby behavioral responses to the presence of an AUV.

Brandon E Monteiro and Julian Aherne, Trent University. **Abundance and Characteristics of Microplastics in Urban Stormwater Ponds.**

It is estimated that thousands of tons of plastic and microplastics (MP) enter the Great Lakes each year. The primary pathways of MP to the Great Lakes are through wastewater discharge, atmospheric deposition, and urban runoff directly into waterways. In urban areas, stormwater ponds (SWP), artificial bodies of water, are designed to mitigate floods, retain pollutants, and collect urban runoff from their surrounding area. In the Greater Toronto Area, little is known about MP abundance in SWP and their capacity to retain and redirect MP from entering Lake Ontario. To understand the role of SWP in the MP cycle, we examined surface water in SWP (n=12) within the Etobicoke Creek Catchment, which extends from Caledon to Toronto and drains into Lake Ontario. Within the Etobicoke Creek Catchment, SWP 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 (shape, size, and polymer) of MP in SWP associated with different dominant land use types. This will inherently provide context on the sources of MP entering Lake Ontario.

Dani Montocchio and Patricia Chow-Fraser, McMaster University. **Where's Walleye? The search for a modern fish survey technique to study ghost forests in coastal wetlands.**

Nets have been used to capture fish since the Stone Ages, however, due to climate change altering the hydrological regimes of the Laurentian Great Lakes, researchers may need a more modern solution to survey fish communities. Once rare, patches of ghost forests have increased on the nearshores of Georgian Bay coastal wetlands, created by a sustained low-water period. Once water-levels rose, these inundated meadow species (IMS) made past net survey techniques ineffective. As such, our lab has developed an underwater camera array which is no longer depth-dependent and is less invasive to fish communities. In 2022, 10 coastal wetlands with ghost forest patches were sampled with this array using a paired design, where a camera stand was placed in-front of the IMS and another behind. After collecting thousands of hours of videos, we partnered with Zooniverse, creating the online citizen project, "Where's Walleye?", to pre-process the collected footage. We hypothesize that the more rigid structure of the IMS may reduce fish access to the nearshore of coastal wetlands, where smaller and younger fish species are expected to be found in greater proportions behind the IMS than in-front. This project not only aims to address how ghost forests in freshwater coastal wetlands may impact fish communities, but can also be used as a pilot study, to address the increasing challenge of handling big datasets and how citizens can contribute to science.

Markelle Morphet[1], Ryan Lauzon[2] and Nicholas E. Mandrak[1], [1]University of Toronto Scarborough, [2]Chippewas of Nawash Unceded First Nation Fisheries Assessment Program. **A bottle full of Dikameg: A collaborative effort to monitor a spawning Dikameg population and a potential egg predator using environmental DNA barcoding in Saugeen Ojibway Nation Territory.**

Dikameg (Lake Whitefish, *Coregonus clupeaformis*) has been harvested by the Saugeen Ojibway Nation (SON) since time immemorial. However, Dikameg populations in northern Lake Huron and Georgian Bay have declined since the 1990's, a tremendous concern to the SON given the importance of Dikameg to food sovereignty, culture and economy. The SON Joint Fisheries is in the process of investigating the role of Dikameg in the Lake Huron food web, which has shifted in the past few decades due to exotic species introductions and sport fish stocking. Our collaborative project was initiated by discussions on how environmental DNA (eDNA) can be implemented to

address the Dikameg research interests of the SON community. Together, we developed methods and strategies to investigate the capability of eDNA barcoding to detect changes in concentrations of Dikameg and Round Goby (*Neogobius melanostomus*), a potential egg predator, over the progression of the Dikameg spawning season. All aspects of the project, including methodology, were informed by Western science and SON knowledge. For example, SON knowledge informed our approaches to fish collection and sampling-site selection, which has been essential to the feasibility and timeliness of our project. This research was built on foundations of inclusivity, equitability, and meaningful communication and will continue to be essential to its success.

Andrew Muir[1] and Abigail Lynch[2], [1]Great Lakes Fishery Commission, [2]U.S. Geological Survey.
Everyone needs a graduate student.

We introduce a session celebrating the contributions of Dr. William W. Taylor, Michigan State University and highlight notable achievements in teaching and mentorship, service, inland fishery management, and international engagement. We present a few highlights from Dr. Taylor's career and relay a number of anecdotes and stories from former students and colleagues that underscore his keen skills in negotiation, delegation, and unique approach to experiential teaching and learning. Dr. Taylor's steadfast belief that anything is achievable could in some instances overlook 'minor' challenges of actually meeting his end vision. We offer brief insights into the life of our distinguished colleague and friend to kick-off a celebration of his dedication to Laurentian Great Lakes science and scientists.

Mohiuddin Munawar, Martin Van der Knaap, Iftekhar Fatima Munawar, Jennifer Lorimer, Lisa Elder, Susan Blunt and Jahanara Shaikh, Aquatic Ecosystem Health & Management Society.
Celebrating Professor Taylor's partnership with the Aquatic Ecosystem Health & Management Society.

It is an honor to celebrate the glorious academic career of Professor W. Taylor who had a tremendous global impact on fisheries science. His partnerships included Aquatic Ecosystem Health & Management Society (AEHMS), as both a senior advisor and member of the editorial advisory board. The AEHMS acknowledges his incredible, solid support and collaborations with its journal, Aquatic Ecosystem Health & Management. He helped organize and edit 3 special issues dealing with fishes, fisheries and governance including one celebrating the legacy of Dr. Henry Regier. He also helped organize two special issues on the ecosystem services of fish, cultural and economic perspective in North and South America, Europe, Africa and Asia. He recently served as co-chair of a special session dealing with the blue economy at the Ecosystem Approach conference in Windsor which in turn contributed papers to a forthcoming special issue. His undaunted support of AEHM as a senior advisor in producing high quality science is quite evident. This presentation will highlight his contributions to ecosystem-based science via AEHMS gratefully. Bon voyage, bon sante and best wishes for a fruitful retirement.

Mohiuddin Munawar[1], Hedy Kling[2], Mark Fitzpatrick[1], Heather Niblock[1] and Mike McKay[3], [1]Fisheries and Oceans Canada, [2]Algal Taxonomy and Ecology, Inc., [3]University of Windsor. **A maiden winter journey into the Great Lakes: Exploring unknown floristic communities.**

A novel bi-national winter sampling program was initiated by the University of Minnesota in conjunction with several scientists across the Great Lakes. Fisheries and Oceans Canada offered to undertake taxonomic analysis of about a dozen phytoplankton samples following the standard Utermöhl technique. The majority of stations contained low biomass, typically in the range of 100 - 400 mg m^{-3} and the Lake Superior sites had the lowest biomass (<100 mg m^{-3}). The highest

concentrations of phytoplankton (1600 - 17000 mg m^{-3}) were found in Green Bay, Hamilton Harbour and central Lake Erie, habitats typically associated with summer eutrophication. The total number of species identified generally ranged from 9 to 31 and overall the diversity appeared to be low. The winter flora was dominated by phytoflagellates (Cryptophyceae, Chrysophyceae, Dinophyceae), Diatoms and Chlorophyta. Overall, Chrysophyceae and Cryptophceae as well as Diatoms were the most common. A more detailed discussion of the species composition will be included in the presentation. Many of the observed species were very minute forms (i.e. small sized picoplanktonic and nanoplankton) which were difficult to identify by light microscopy. These data expose the community structure of winter algae in the Great Lakes which has not been well studied and provide a baseline for future winter studies.

Asmita Murumkar[1], Anna Apostel[2], Margaret Kalcic[2], Jay Martin[1], Haley Kujawa[1], Vinayak Shedekar[1], Kevin King[3], Kevin Czajkowski[4], Kimberly Panozzo[4] and Ishfaq Rahman[4], [1]The Ohio State University, [2]University of Wisconsin-Madison, [3]United States Department of Agriculture - Agricultural Research Service, [4]University of Toledo. **Assessment of conservation practices program using a high-resolution SWAT model in Western Lake Erie basin, USA.**

The Great Lakes Water Quality Agreement (GLWQA) set a target of a 40% reduction in agricultural nutrient loadings to Lake Erie's Western Basin from March through July to address harmful algal blooms (HABs). The State of Ohio launched an H2Ohio program to meet this water quality goal by incentivizing the top 10 conservation practices focusing on nutrient, erosion, and water management. However, the potential effectiveness of watershed-scale adoption of these practices is unknown. The high-resolution watershed model is a crucial tool to assess the effectiveness of these management practices and programs to achieve nutrient reduction targets. We used high-resolution remote sensing (crop rotation and tillage practices and emerging data sources (manure and fertilizer application, soil test phosphorus level, drainage parameter) related to crop management practices to build a field-scale Soil and Water Assessment Tool watershed model for the Maumee River Watershed to analyze the impact of H2Ohio program. Using USGS data, the model was calibrated and validated at the outlet and upstream gauges for flow and water quality parameters and validated for conservation practice effectiveness at the field scale using edge-of-field data. The state input has been included in the development of conservation practices model scenarios. Further advice from a broad group of stakeholders is being sought, and results will be disseminated to and through H2Ohio and the Ohio DAP.

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Herbert Nakiyende[1], Anthony Basooma[1], Chrispine Nyamweya[2], Winnie Nkalubo[1] and Lauren Chapman[3], [1]National Fisheries Resources Research Institute, [2]Kenya Marine and Freshwater Research Institute, [3]McGill University. **Navigating Data Gaps: Employing Stock Assessment Models for Sustainable Artisanal Fisheries in Lake Albert, East Africa.**

Achieving resource sustainability in data-poor fisheries remains a global challenge, leading to adoption of stock assessment models to navigate data limitations. Models are yet to be applied on Lake Albert, a data-deficient African Great Lake with a species-rich artisanal fishery. In this study, we employ Virtual Population Analysis (VPA), Schaefer, Fox, and Catch MSY models, to establish growth parameters and biological reference points for *Engraulicypris bredoi* and *Brycinus nurse* in Lake Albert, utilizing fishing, effort, fish length and catch data. The study revealed comparable estimates among models, indicating their appropriateness for informing the lake's management decisions. The

estimated maximum sustainable yield (MSY) for *B. nurse* ranged from 34,469 tonnes (t) to 37,599 t, while for *E. bredoi,* it ranged from 83,587 t to 90,858 t. The MSY and fishing effort at MSY exceeds the current levels, while fishing mortality and exploitation rate are below thresholds of F01, F05, and Fmax, pointing to underfishing and potential for heightened catch and effort. However, the vulnerability of *B. nurse* to fishing mortality at a smaller size before reproductive maturity raises concerns over its sustainability. These findings indicate generally health stocks of *E. bredoi* and *B. nurse*, under low exploitation pressure, while underscoring the need for species-specific licensing, robust regulations consistent with a multi-species fishery, regular monitoring, and comprehensive assessments to understand ecosystem dynamics for the long-term sustainability.

Allison Nalesnik[1], Emily Martin[2], Nicholas Johnson[3], Emma Carroll[1], William Hemstrom[1], Erin Dunlop[4], Marisol Sepulveda[1] and Mark Christie[1], [1]Purdue University, [2]University of California, Irvine, [3]United States Geological Survey, [4]Ontario Ministry of Natural Resources and Forestry.
Larger larval Sea Lamprey have longer survival times when exposed to the lampricide 3-trifluoromethyl-4-nitrophenol.

Invasive sea lamprey (*Petromyzon marinus*) in the Great Lakes have been a longstanding ecological concern, with significant impacts on native species. To mitigate this, 3-trifluoromethyl-4-nitrophenol (TFM) has been employed as a lampricide for decades. This study investigates the survival rates of larval sea lamprey in response to TFM exposure, with a focus on detecting early signs of incipient resistance. An experiment was conducted with 8,604 ammocoetes across four temporal replicates. Our methodology included exposure durations up to 18 hours and controlled TFM concentrations. Our findings describe a significant correlation between the size of larval sea lamprey and their survival times to TFM. Specifically, larger larvae exhibited longer survival periods when exposed to the lampricide. The overall linear mixed effect model including total length, mass, and their interaction was significant (p-value < 0.001) and explained (conditional R^2) 71.42% of the variation in survival time in TFM. The observation of longer survival times in larger larval sea lamprey exposed to TFM raises concerns about the early stages of incipient resistance. This phenomenon could have substantial implications for ongoing sea lamprey control programs in the Great Lakes. Our results underscore the need for continuous monitoring and potential adaptation of control strategies to ensure effective management of this invasive species.

Jean N Namugize and Michael Kizza, Nile Basin Initiative Secretariat. **Water quality and sediment monitoring in the Nile Basin countries.**

Water quality deterioration is an issue in the Nile basin countries as it is elsewhere in the world and is ascribed to point sources and non-point sources of pollution. Lack of funding resources to support implementation of regional water and sediment monitoring programs; inadequate systems for data acquisition, management, processing and dissemination of water quality results and information to the end users are some of the challenges in the basin. This study seeks to understand the current situation of national and regional water quality and sediment monitoring programs in nine out of 10 countries of the Nile Basin. A situation analysis that combines review of literature and field visits was conducted in the nine riparian countries of the Nile basin over a period of nine months, from July 2022 to March 2023. Results indicate inconsistency in the collection of water quality data, the monitoring frequency varies from a country to another, basic physical chemical and bacteriological parameters are generally measured, lack of reagents and funding resources, lack of advanced laboratory equipment that can measure the pollutant of big concerns like heavy metals and pesticides. Where advanced laboratory instruments exist, they are not functioning due to inadequate maintenance and lack of spare parts or reagents. This highlights the need for

capacity building of laboratory technicians in operation and maintenance of equipment, initiation of the inter-laboratory proficiency testing schemes in the region.

Kayden Nasworthy[1], James Watkins[1], Thomas Evans[1], Hannah Blair[1], Lars Rudstam[1] and Peter Esselman[2], [1]Cornell University, [2]United States Geological Survey. **Vertical distribution and migration of *Mysis diluviana* in the upper Great Lakes assessed from uncrewed surface vessels.**

Mysis diluviana are large zooplankton predators and play a critical role in many of the Great Lakes' food webs as both a predator and key prey item. These animals perform diel vertical migration in response to light and their distribution is limited by both light and temperature. However, most studies of the fine fine-scale vertical distribution and migration behavior of these organisms were conducted in Lake Ontario. Hydroacoustic data collected from uncrewed surface vessels in Lakes Superior, Huron, and Michigan in the summers of 2022 and 2023 allow for high-resolution analysis of Mysis spatial distribution and migration behavior. The availability of this data provides unprecedented information on the variability in mysid migration. We expect that vertical distribution and migration behaviors are dependent on both environmental factors such as light and temperature, as well as physical drivers such as proximity to predators/prey. Implementing USV-based hydroacoustics can contribute more comprehensive understanding of Mysis spatial ecology and its ecological significance within the Great Lakes ecosystem.

Kim Nelson[1], Cheryl Nenn[2], Meg Maffitt[1], Andrea Lyon[1] and Amy Alvarez[1], [1]True Elements, [2]Milwaukee Riverkeeper. **Title: Maximizing the Value of Lake Erie Water Data Through Water Intelligence.**

Advancements in water sensor and monitoring technology are rapidly generating more specific and abundant water data within the Lake Erie Basin daily. Optimizing captured data is critical for its highest purpose - providing essential insights for sound, collaborative decision-making in support of the health and resilience of the Lake Erie Basin. True Elements' Water Intelligence platform, built to open API and FAIR standards, provides a single, easy to use platform that pulls data from any source together with existing datasets, translating water's complex, multi-dimensional interrelationships into clearly understandable visualizations and scores for reliable analysis and forecasting. A recent case study involving Milwaukee Riverkeeper demonstrates the efficacy of the platform. Milwaukee Riverkeeper invested significant time and resources in compiling water quality data for analysis, decision-making, and communication with watershed stakeholders. Recognizing the need for a more efficient process, they sought a solution to expedite data aggregation, analysis, and information sharing and enhance the utility of their data for deeper insights. In 2023, Milwaukee Riverkeeper leveraged True Elements' Water Intelligence platform to streamline the aggregation, visualization, and real-time utility of their data. The platform's data layering capabilities created clearer context and broader perspective, yielding the deeper insights the Riverkeepers sought. If selected, True Elements and Milwaukee Riverkeeper will share at IAGLR the findings of this case study and discuss how the platform could be used to support the Lake Erie Basin.

Cheryl Nenn, Milwaukee Riverkeeper. **Community Based Water Quality Monitoring in the Milwaukee River Basin.**

Milwaukee Riverkeeper has created and coordinated a community-based water quality monitoring program since 2006, with 90-100 volunteers monitoring over 100 sites each year in the Milwaukee River Basin. Many individuals have monitored their sites for a decade or more, serving as experts on their section of river--reporting pollution, discovering water main breaks and reporting

illegal dumping. The Wisconsin Department of Natural Resources has used our data to determine which rivers are impaired, or not meeting goals designed to ensure aquatic health. Our data has identified over 117 miles of river as impaired for chloride, 370 miles impaired for phosphorus, and 108 miles impaired for bacteria. Our water quality data has informed Total Maximum Daily Loads (TMDLs), which are pollutant reduction plans that are enforceable by US EPA and state agencies. Our data helps identify sources of pollution as well as best management practices (e.g., fixing leaky sewers and failing septic, minimizing agricultural runoff, etc.) and policy solutions that are needed to improve water quality. Our data helps assess long-term trends, such as warming water temperatures that threaten coldwater fisheries, and helps spur research and collaborative solutions needed to protect our streams and make them more resilient to climate impacts. We also issue annual report cards to make our data accessible to people, so they can make better decisions for their families and communities.

Michelle Neudeck[1, 2] and George Bullerjahn[1, 2], [1]Bowling Green State University, [2]Great Lakes Center for Fresh Waters and Human Health. **Comparison of HAB metatranscriptomes in Sandusky Bay, Lake Erie from 2018 and 2019.**

Harmful algal blooms have plagued Sandusky Bay on Lake Erie since the early 2000's. *Planktothrix agardhii* is usually the dominant species. The bay averages a depth of 2m and has high rates of sedimentary denitrification that leads to nitrogen limitation much of the summer (Salk et al. 2018, Hampel et al. 2019). Microcystin concentrations have, on occasion, exceeded the recreational contact guidelines. Sampling was conducted in the bay every two weeks from June to September in 2018 and 2019. DNA was extracted from these sites and sequenced for 16S rRNA genes for identifying the taxonomy of the microbial community. The analysis revealed a *Planktothrix* bloom in 2018, but there was a more diverse cyanobacterial community in 2019. RNA was extracted from separate filters and sequenced for metatranscriptomic analyses. Differential expression of these metatranscriptomes from 2018 and 2019 were compared for nitrogen cycling and other pathways. *Planktothrix* was predominant in 2018. In early June of 2019 *Planktothrix* showed high expression rates, but *Anabaena* and *Microcystis* typically had a greater expression than *Planktothrix* for these pathways in July, August and September.

Alex Neumann, Akunne Okoli, Odai Al Balasmeh and George Arhonditsis, University of Toronto. **Development of SPARROW model in the Canadian side of Lake Erie basin.**

SPAtially Referenced Regression On Watershed attributes model (SPARROW) has been applied in Canadian side of Lake Erie basin. The dedicated model is designed to process only information from withing the study area in order to support adaptive watershed management and provide data-driven evidence of nutrient loading reduction across the watershed in addition to tributary water quality collected at the outlets of main tributaries. The SPARROW model is intended to estimate nutrient export coefficients based on existing tributary water quality monitoring data, as operated by provincial and federal governments of Canada. The model considers different predictors for land-to-water delivery, which could explain spatial variability of export coefficients across the study area. The model allows us to assess the contribution of different non-point and point sources in the delivered total phosphorus budget and classify priority management areas. The derived nutrient losses can formulate the platform for assessing performance of candidate models in watershed modeling ensemble.

Silvia Newell[1], Justin Myers[2], Morgan Grunden[2], Lauren Kinsman-Costello[3] and Stephen Jacquemin[2], [1]University of Michgan, [2]Wright State University, [3]Kent State University. **Assessing Nutrient Load Reductions in H2Ohio Constructed Wetlands: Case Studies from Brooks Park and the Burntwood- Langenkamp Wetlands.**

Wetlands perform critical ecosystem services, including nutrient reduction, flood mitigation, and biodiversity habitat. The H2Ohio Initiative through the Ohio Dept. of Natural Resources in part funds wetland restoration to improve water quality through nutrient reduction. The Lake Erie and Aquatic Research Network (LEARN) Wetland Monitoring Program is monitoring a subset of the wetlands to evaluate nutrient reduction. This work focuses on nutrient dynamics at two wetlands. Brooks Park, flowing into hypereutrophic Buckeye Lake. Murphy's Run creek flows through Brooks Park wetland, draining a very small watershed (1.2 mi^2), and behaves as a flow-through or a coastal wetland. Preliminary data indicates that the wetland is a sink for total nitrogen (3335±442 lbs N in 2022 and 385 ± 85 in 2023) but net neutral for total phosphorus (84±98 lbs in 2022 and -2±5 lbs in 2023). The 90-acre Burntwood-Langenkamp Wetland Conservation Area in the Grand Lake Saint Marys watershed. This site is a former corn/soybean field. Burntwood-Langenkamp Wetland drains approximately 5,700 acres of watershed land. Total Nitrogen (TN) at the outflow is ~73% lower than the inflow, equating to a load reduction of 2680 lbs of N in 2023. A decrease thus far of ~55% in SRP concentration, and a TP reduction of 14.7 lbs P for 2023. Nutrient load reduction will likely vary as the wetlands mature, but preliminary data indicate that both wetlands are performing a vital ecosystem service.

Amber M. B. Ng[1], Rachel A. Hackett[1], Paul R. Schilke[1] and Rochelle A. Sturtevant[2], [1]Michigan Natural Features Inventory, [2]Michigan Sea Grant. **A checklist of aquatic vascular plants in the Laurentian Great Lakes.**

Annotated species checklists are an important resource for conservation managers and researchers. They can act as a reference for field surveys and environmental DNA analysis, provide life history information, and promote comparisons between regions. Existing vascular plant guidebooks and floras follow a terrestrial perspective, documenting the land area and political boundaries across which species are spread. These resources cannot answer the question of whether a particular species is found in a specific Great Lake or its coastal wetlands. The Great Lakes Water Life database (https://www.glerl.noaa.gov/data/waterlife/) already provides such lake-based distribution information for invertebrates, fish, herps, zooplankton, and algae of the Laurentian Great Lakes. NOAA, Michigan SeaGrant, and Michigan Natural Features Inventory partnered to expand this database to include vascular plants. We aggregated, cleaned, curated, and verified data from regional research, preserved specimens, natural heritage programs, and published literature. The resulting information will be added to the Great Lakes Water Life Explorer, and published as a Darwin-Core Archive to promote transparency and FAIR (findable, accessible, interoperable, reusable) data principles. Patterns of biodiversity and species distributions revealed by this process raise new questions and illuminate areas in need of future research.

Maxon Ngochera[1], Benjamin Ngatunga[2], José S. Halafo[3], Theodore Lawrence[4] and Geoffrey Chavula[5], [1]Department of Fisheries, [2]Tanzania Fisheries and Aquatic Environment Organization, [3]Oceanography Institute of Mozambique, [4]African Center for Aquatic Research and Education, [5]Department of Civil Engineering, Malawi University of Business and Applied Sciences. **Past and present research initiatives in Lake Malawi/Nyasa/Niassa: Opportunities and challenges in conducting transboundary research.**

Malawi, Mozambique, and Tanzania share one of the largest freshwater lakes in the world: Lake Malawi/Niassa/Nyasa ((LMNN) respectively. Due to its multi-jurisdictional nature, LMNN faces challenges of disparate research efforts and capacity by the three different countries, often leading to imbalances in contributions, benefits, and only a partial understanding of the resource as a whole. The need for transboundary research is essential, as such efforts enhance understanding of the whole lake, and increase the overall research capacity and efficiency through expertise, infrastructural, and data sharing. Results from transboundary research can better inform policy decisions at both national and regional levels, leading to more effective and coordinated interventions. While transboundary collaborations are necessary on multi-jurisdictional lakes, challenges exist, including obtaining approvals and permits for research activities through differing regulatory frameworks and bureaucratic processes across borders. Additionally, data sharing management, ownership, privacy, and intellectual property, become complex when multiple stakeholders are involved. On some resources, including LMNN, the additional political tensions between countries may affect the willingness to collaborate, potentially hindering effective transboundary research. In this talk, we will discuss existing opportunities and specific challenges on LMNN and the creation of a scientific-driven approach that involves strong institutional support, clear communication, and the development of a framework for collaborative research that takes into account the unique context of transboundary studies in the LMNN basin.

Hang Nguyen, Amir Reshadi, Stephanie Slowinski, Fereidoun Rezanezhad and Philippe Van Cappellen, Ecohydrology Research Group, Water Institute and Department of Earth and Environmental Sciences, University of Waterloo. **Controls on microplastics accumulation in stormwater pond sediments.**

In urban watersheds, stormwater runoff is a major carrier of microplastics to downstream water bodies, which often drains into green infrastructure such as stormwater ponds (SWPs). However, the effectiveness of SWPs in retaining different microplastic (MP) types and shapes remains understudied. The aims of this study were to ((1) assess the variability in MP accumulation rates in sediments within and between SWPs, and (2) determine the influence on MP accumulation of SWP characteristics, including land use and land cover (LULC). We collected sediment samples from five SWPs located in the Grand River watershed with different LULC. MPs were separated from the sediments using a density-based separation method and then analyzed by laser direct infrared spectroscopy. The results revealed that MP accumulation rates in the SWPs' inlet forebays were 2-5 times higher than in the main basin for the majority of the SWPs, and industrial ponds exhibited the highest sediment and MP accumulation rates. Additionally, fragments were found to be the dominant MP particle shape in all SWPs sediment. MP concentrations showed a positive correlation with sediment grain size and sediment organic carbon concentrations, reflecting the influence of sediment properties on MP accumulation rates. This study provides insight into the influence of catchment and sediment properties on the accumulation of MPs in SWP sediments and into the role of SWPs as accumulators of MP pollution in urban environments.

Shayenna Nolan[1], Sue Chiblow[2], Clint Jacobs[1], Candy Donaldson[1], Daniel Heath[1] and Catherine Febria[1], [1]University of Windsor, [2]University of Guelph. **Decolonizing river health and governance: Indigenous-led freshwater assessments using community input and science tools.**

Indigenous peoples have been actively coexisting with ecosystems for millennia, but the era of the Anthropocene and settler-colonialism has led to intensive land use pressures that have severely impacted terrestrial habitats and freshwater ecosystems. Often overlooked, small streams

and headwaters comprise approximately 75% of global watercourse length and provide ~55% of the water volume in larger rivers, highlighting their considerable influence on the health of downstream water bodies such as *Nayaano-nibiimaang Gichigamin* (Great Lakes in *Anishinaabemowin*). While streams and rivers are critical for sustaining life, they are also highly sensitive to stressors resulting from colonization. In Canada, the settler-colonial water governance frameworks responsible for assessing river health and protecting water have long excluded Indigenous knowledge and participation. Given the responsibility that Indigenous peoples have to water, and the inherent rights of water in Indigenous natural laws, there is a need to move beyond colonial frameworks and heal our relationship with water and improve the ways in which we care for it. Here I describe an Indigenous-led project to reimagine traditional stream and river assessments in partnership with the communities of Batchewana, Garden River, and Six Nations. Combining molecular and microbial tools and community input at every step of the process, this project and seeks to answer the question: What does it mean to decolonize river health and governance?

Brendan F. O'Leary, Glen Ray Hood, Carol J. Miller and Sarah M. Black, Wayne State University.
Investigating Groundwater Contamination through Phytoscreening in Neighborhoods of the Great Lakes Region.

The nationwide prevalence of brownfields, expanding at a rate greater than their associated delineation, remediation, and closure, highlights the need for more efficient screening methods that can be used to prioritize focused site investigation. These brownfields are a significant source of contamination within the post-industrial cities of the Great Lakes Basin and pose a threat to urban groundwater. Phytoscreening, which uses plants to screen for belowground chemical contaminants, has emerged as a viable method for detecting anthropogenic volatile organic compounds (VOC) in complex urban environments at reduced costs and times compared to conventional methods (e.g., groundwater monitoring wells and soil cores). However, the relationship between subsurface concentrations and those measured in co-located plants is not yet fully understood. Our research, centered in Detroit, aims to establish whether plant tissue can be used to screen for belowground VOC concentrations. Initial results are promising, with positive detection of VOCs in a suite of common plant species present at brownfield sites. Additional work is being conducted to investigate concentration changes with the growing season and environmental conditions such as heavy rains and droughts. In conclusion, there are over 450,000 USEPA registered brownfields, and phytoscreening offers a promising method for detecting VOCs in these areas.

Cooper O'Rourke[1], Alex Smith[1] and Chris Houser[2], [1]University of Windsor, [2]University of Waterloo. **Quantifying the Rates of Historical Shoreline Change on the North Central Basin of Lake Erie.**

Lacustrine environments such as the Laurentian Great Lakes are increasingly influenced by the processes of coastal erosion. Large amounts of land have been lost to this erosional process, particularly in Lake Erie, leading to the closure of many roads and the destruction of property. The effects of this coastal process may increase with a changing climate as winter ice coverage is reduced, leading to increased erosion of shorelines during winter storms. This erosion is apparent on Lake Erie's northern shore, where there have been vast amounts of coastal change throughout its history as well as large amounts of shoreline modification such as jetties, which disrupt sediment transport pathways by creating an artificial barrier. These coastal structures have been found to be a major

contributor to the erosion of shorelines and bluffs downdrift of said infrastructure. Monitoring and quantifying this change in shoreline position is important for predicting impacts on this northern shore and the influence that coastal infrastructure has on the erosional process. To quantify this change through time, a historic analysis was conducted, but with a lack of arial imagery for earlier periods, the use of georectified historical maps were utilized. By digitizing these historical shorelines in a geospatial software and measuring their change through time, predictions can be made based on past changes to predict future processes and could influence decisions regarding the management of this northern shoreline.

Julia Akinyi Obuya[1], Horace Owiti[2], Mark Olokotum[3], Brittany Zepernick[4], Kaela Natwora[5], Dennis Otieno[1], Winnie Owiko[1], Doreen Achieng[1], Patrick Otuo[1] and James Last Keyombe[1], [1]Kenya Marine and Fisheries Research Institute, [2]Cornel University, [3]National Fisheries Resources Research Institute, [4]University of Tennessee Knoxville, [5]University of Minnesota Duluth.
Socioeconomic consequences of cyanobacteria harmful algal blooms in small-scale fishing communities of Winam Gulf, Lake Victoria.

Lake Victoria has experienced progressive eutrophication which has exacerbated the proliferation of cyanobacterial harmful algal blooms (cHABs). Fueled by anthropogenic nutrient loadings and climate change, these cHABs are increasing in distribution, duration, and frequency throughout the lake, particularly in areas such as the Winam Gulf. With limited resources and infrastructure, local communities have been left vulnerable as they rely on the lake for water, food, and income. Our study presents the results of a localized survey on how small-scale fishing communities perceive and respond to the threat of cHABs in the Winam Gulf of Lake Victoria, Kenya using a mixed-methods approach. Results demonstrate most (93.67%) respondents were aware of cHABs in the lake but were not knowledgeable of cHAB threats to human and animal health. Respondents noted cHABs decreased fish catches, with this economic consequence serving as a primary concern of communities. Notably, respondents altered their use of lake water during perceived cHAB events and relied on various means of water treatment or alternative water sources. Overall, cHAB information was self-sourced or passed on from community elders, with no public mechanism for adequate cHAB risk communication. Lake Victoria serves as a critical resource to the Eastern African continent and requires a concerted cHAB response effort. Therefore, we recommend the development of a public awareness program for risk and hazard communication to reduce cHAB exposure in these at-risk communities.

Bruno Odhiambo[1], Zadock Omach[2] and Winnie Owoko[1], [1]Kenya Marine and Fisheries Research Institute, [2]Stony Brook University,NY USA. **Nitrogen and Phosphorus Co-Limitation in Eutrophic Lakes: A Case Study of Lake Victoria.**

This study discusses the intricate dynamics of nutrient limitation in the context of eutrophic lakes, using Lake Victoria as a representative model. Eutrophication, driven primarily by excessive inputs of nitrogen and phosphorus, has become a pervasive issue in freshwater ecosystems worldwide. This research employs a comprehensive approach, combining field surveys, water quality analyses, and ecological modelling, to investigate the prevailing nutrient dynamics within Lake Victoria. Our findings reveal a high probability of nitrogen and phosphorus co-limitation, shedding light on the complex interplay between these essential nutrients in sustaining aquatic ecosystems. Through vigorous data collection and advanced analytical techniques, we explore the spatial and temporal variations in nutrient concentrations, phytoplankton dynamics, and other relevant limnological parameters. The study underscores the significance of considering both nitrogen and phosphorus as potential limiting factors in eutrophic lakes, challenging conventional approaches that

often focus on a single nutrient. In conclusion, this case study contributes to the growing body of knowledge on nutrient dynamics in eutrophic lakes, emphasizing the importance of adopting a nuanced perspective that accounts for the co-limiting nature of nitrogen and phosphorus. The insights gained from Lake Victoria serve as a valuable reference for limnologists, ecologists, and policymakers striving to address the challenges posed by nutrient enrichment in freshwater ecosystems globally.

Mary Ogdahl[1], Aubrey Lashaway[1], Nicole Rice[2], Abigail Goodman[1] and Margaret Throckmorton[1], [1]University of Michigan, Cooperative Institute for Great Lakes Research, [2]NOAA Great Lakes Environmental Research Laboratory. **Investing in the Future of the Great Lakes: The Next Generation of Scientists.**

Over the last 25 years, NOAA GLERL has supported more than 1,000 training opportunities for students and postdocs from more than 100 universities across the globe in partnership with the University of Michigan's Cooperative Institute for Great Lakes Research (CIGLR). Through immersive, hands-on research experiences that span the Great Lakes' most pressing issues, NOAA GLERL and CIGLR have inspired numerous students and early scholars to pursue research careers in the Great Lakes and beyond. With support from NOAA GLERL and the University of Michigan, CIGLR provides NOAA-mission related research experiences to students and postdocs through our Engagement, Career Training, and Outreach Program, including fellowships, graduate student projects and theses, and employment on research teams. CIGLR leverages our Regional Consortium to expand our reach to students and postdocs across the Great Lakes basin and on both sides of the border, in mutually beneficial partnerships that offer exposure to NOAA research while broadening the geographic and disciplinary focus of our training opportunities. CIGLR and NOAA GLERL are committed to increasing diversity and inclusion in STEM fields through our training opportunities by removing barriers and actively encouraging participation by students from groups traditionally underrepresented in aquatic sciences. NOAA GLERL's long-term investment in training the next generation of scientists has produced a highly-skilled Great Lakes scientific workforce that is equipped to tackle the challenges that threaten the future of this critical ecosystem.

Harriet Okeyo, University of Windsor. **Conversion of fish waste to resources.**

Fisheries have always been an important economic subsistence activity all over Africa and support over 150 million Africans directly or indirectly through food and income, hence the need for proper management and maximum use of the by-products. In this sector, post-harvest management lags. Moreover, by-products and waste from the industry lie underutilized, despite their potential to spur economic growth in the sector. The fish's biowaste accounts for about 40% of its body mass. These 'wastes', usually from markets and filleting industries, are disposed of, leading to environmental pollution during decay. This has seen a loss in the value of these products, wastage from decay, and a loss of economic potential. Preliminary studies showed that fish wastes contribute a three-fold higher concentration of nutrients (nitrates, nitrites, and phosphorus) compared to other biological wastes of the same quantity. The nutrients are the main drivers of algal blooms, which come with further emission of greenhouse gases when decaying and cyanotoxins. This threatens the local people, who depend on direct water from the lake for drinking and other domestic uses. The conversion of 'fish wastes' into value-added products, will in turn contribute to environmental sanitization as the wastes are taken from the environment and used to make valuable products, food security and economic empowerment through creation of job opportunity thereby contributing to the achievement of sustainable food systems and healthy nutrition.

Akunne Okoli, Odai Al Balasmeh, Alex Neumann and George Arhonditsis, University of Toronto. **Spatiotemporal Dynamics of Total Phosphorus Load in the Canadian Side of Lake Erie Basin.**

Managing nutrient load in Lake Erie is central to the ongoing binational agreement between the United States and Canada to mitigate the adverse effects of eutrophication and enhance the overall water quality and ecosystem health. In line with this, a comprehensive understanding of spatiotemporal patterns in phosphorus (P) loading is crucial to track the effectiveness of current nutrient reduction programs, monitor progress, and inform future watershed management policy. In this study, we present a quantitative assessment of tributary phosphorus load and its associated uncertainties in the Canadian side of the Lake Erie basin. Utilizing daily phosphorus and flow datasets from the existing network of tributary water quality monitoring stations and stream gauges spanning 22 water years (2000-2021), we apply different load estimation methods to subbasins of gauged and ungagged locations. For gauged subbasins, we employ Regression Load Estimation (LOADEST) and Beale's ratio estimator (run on the Erie Loading Tool). For the ungauged subbasins, we formulate a flow-catchment regression model to project annual flow rate and subsequently compute the P load estimates based on the posterior simulations. Our analysis aims to reveal potential disparities in load estimation with the three methods, evaluate the influence of data quality, and identify crucial monitoring gaps. The anticipated findings from this study are expected to offer valuable insights to help guide actions toward developing long-term watershed management plans.

Alex Okolocha and Anthony Okoye, Nnamdi Azikiwe University. **Emerging contaminants, Perfluoroalkyl and polyfluoroalkyl — PFAS under changing climatic variability: Insights from a preliminary survey in Agulu Lake, Anambra State, 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 health, studies monitoring these contaminants in Africa, including Nigeria, remain scarce. here, 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 analyzed 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 to developing an effective regional strategy for managing PFAS influence in freshwater ecosystems in Nigeria.

Joshua Olowoyo, Western University. **Catalytic effects of Iron-based particles on the combustion of crude oils: an approach for oil spill response.**

According to the Canada Energy Regulator (CER), over 80% of the crude oils within Canada are transported to end users through a 68,000 km network of pipelines that cross various geographical landscapes including mountains, rivers, lakes, wetlands, and estuaries. In response to oil

spill incidents, particularly when mechanical cleanup efforts encounter logistical challenges, in-situ burning (ISB) has been identified as a potential alternative approach. However, the primary obstacle to implementing ISB in inland water environments lies in the substantial smoke plume it produces, giving rise to concerns about the health and safety of local residents. This study systematically investigates the catalytic role of iron-based particles in promoting fuel combustion and the suppression of smoke production through the utilization of differential scanning calorimetry, thermogravimetric analysis, and pyrolysis-gas chromatography techniques.

Ojietu Omone, University of Benin. **Taxonomic and Trait-based Responses of Invertebrate Odonate to Fine Sediment Stress and Grain-sizes in Afrotropical Rivers: Insights from the Niger Delta Region, Nigeria.**

Sedimentation in rivers and streams is an important stressor impacting freshwater ecosystems. We explore the taxonomic and trait distribution of Odonata taxa in Response to fine sediment grain sizes in eight selected sites in four rivers in the Niger Delta Region, Nigeria. We sampled macroinvertebrates and physicochemical variables from the sites on four sampling occasions. The sites were classified into four site groups (Site Group 1 > Site Group 2 > Site Group 3 >Site Group 4), representing a decreasing gradient of sediment stress. The multivariate combined RLQ and Fourth-corner analysis of Odonata taxa and traits indicated that the taxonomic and trait distribution of Odonates proved useful indicators of sediment stress in the river systems. Taxa and traits differed significantly between the site groups ($p < 0.05$), with anisopteran odonates being more tolerant of sediment stress than the zygopterans.

Nivah Ondieki[1,2], Mercy Chepkirui[1,2], Paul Orina[3], Reuben Omondi[1] and Tonny Sagwe[3], [1]Kisii University, [2]Kenya Marine & Fisheries Research Institute, [3]Jomo Kenyatta University of Agriculture and Technology of Agriculture. **Impacts of cage farming on the ecology offshore of Lake Victoria.**

A delicate balance between offshore in-land aquaculture and the environment. A focus on Lake Victoria, Kenya. Global decline in capture fisheries has resulted in development and commercialization of cage farming to meet the ever increasing demand for food insecurity and malnutrition. Despite cage farming attracting many investors in Lake Victoria, Kenya, is likely to emit large bulk of fish waste into the ecosystem and might cause conflict between investors and wild fisheries. Among ecological impacts include: increased eutrophication, genetic pollution of native fish species, changes in flora and fauna community structure, increase spread of fish diseases, antimicrobial resistance and modification of wild stock biomass. Because of these fears, there is need to enforce regulation and policies governing sustainable cage farming to avoid further degradation of the ecosystem. Sustainable practices include: proper site selection, proper feeding regimes, stocking of quality fingerlings, regulation of investment intensity, maintaining good biosecurity measures, community involvement and lake zonation to ensure all stakeholders use the lake without impinging development opportunities for other stakeholders. Support for the sustainable practices in aquaculture should also be sought from Non-Governmental Organizations (NGOs), public, and private sectors to ensure success of cage farming and conserve ecosystem integrity of lake ecosystem.

Onyedika Onwuka, University of Benin. **Investigating the nutrient status of overlying water and sediment of Jabi Lake, Abuja, Nigeria.**

Elevated anthropogenic nitrogen (N) and phosphorus (P) inputs accelerate harmful algal blooms (HABs), posing a global threat to lake ecosystems. Despite extensive restoration efforts,

their impact on nutrient cycles remains unclear. This study conducted a comprehensive investigation of the physicochemical properties of overlying water and sediments in Jabi Lake, Abuja, Nigeria, analyzing a wide range of physical variables across 10 selected sites between 2021 and 2022. Preliminary results revealed significant spatial and seasonal differences. While total nitrogen (TN), total phosphorus (TP), and chemical oxygen demand (COD) concentrations in overlying water met Class III limits of environmental quality standards, indicating relatively good overall water quality, concerns arose regarding potential eutrophication. Explosive chlorophyll-a growth, particularly evident during summer, was observed in certain lake areas. Notably, lakes receiving direct diversion showed lower TN and TP levels compared to non-diverted lakes. This research provides valuable insights into the complex nutrient dynamics and conditions of the lake, contributing to improved understanding of lake ecosystem management and sustainable conservation strategies.

Sophie Orendorf[1], Nathan Hawley[2], Dmitry Beletsky[1], Jia Wang[2] and David Cannon[1], [1]Cooperative Institute for Great Lakes Research, University of Michigan, [2]National Oceanic and Atmospheric Administration, Great Lakes Environmental Research Laboratory. **Analysis of ice-wave-current interactions for Lake Erie 2021-2022 field season.**

Seasonal ice cover in the Great Lakes region has a broad range of ecological and societal consequences through both direct (e.g. navigation, recreation, etc.) and indirect impacts (e.g. lake-effect snow, benthic habitat, etc.). With the harsh meteorological and hydrological conditions of winter in the Great Lakes region, accurate in situ data collection is difficult, especially at fine spatial and temporal scales that can aid in understanding ice processes and improving model performance. This work presents results from a Lake Erie lake ice study for the 2021-2022 winter field season using a blend of in situ measurements, hydrodynamic model analysis, and remote sensing. Concurrent ice, wave, and current data were collected from two Nortek AWAC (Acoustic Wave and Current profilers) in the central basin of Lake Erie. Analysis of the interactions between ice draft, waves, and currents for these AWAC locations will be presented along with comparison to additional observational (e.g., satellite) and model forecast data. Potential improvements for coupled ice-wave models will be discussed. This dataset, and observations like those presented here, are essential for improving coupled ice wave models for the Great Lakes.

Dennis Otieno[1], Ken Drouillard[1], Michael Mckay[1], Linda Campbell[2] and George Bullerjahn[3], [1]Great Lakes Institute for Environmental Research, University of Windsor, [2]School of the Environment, Saint Mary's University, [3]Biological Sciences, Bowling Green State University. **Spatio-temporal patterns of mercury and stable isotope in the lower food web of Winam Gulf, Lake Victoria.**

The trophic structure is an important indicator of aquatic ecosystems health and the lower food web is primarily important since it's a conduit that transfers energy and contaminants to the upper food chain. Samples of lower food web items were collected from Winam Gulf of Lake Victoria, Kenya in 2022/2023 and analyzed for stable isotopes of $\delta^{13}C$, $\delta^{15}N$ and total mercury (THg). Food web samples included unionid mussels (single pool), freshwater shrimp (*Caradina nilotica*) and Omena (*Rastrineobola argentea*) from stations distributed throughout the gulf. Isotope values of $\delta^{15}N$ in mussels and *C. nilotica* were similar (6.89‰ vs. 6.78±0.13‰), while *R. argentea* occupied an elevated trophic position (9.97±0.24‰). Median (5 to 95 percentiles) concentrations of THg were 24.8, 48.4 (37.2 to 63.0) and 50.3 (30.9 to 88.2) ng/g dry weight in mussels, *C. nilotica* and *R. argentea*, respectively. Mercury showed statistically significant between species but modest differences across sites with mean variations values of 1.5 and 2.4 whereas temporal THg concentration (1998 vs 2022/23) within species and over time decreases with a variation of 2.8 and

4.1. Values of $\delta^{13}C$ were enriched in the lower food web indicative of increased eutrophication stress in the gulf through time.

Erin Overholt[1], Nicole Berry[2], Jennifer Schumacher[1], Elizabeth Mette[1], Craig Williamson[1] and Jason Smith[3], [1]Miami University, [2]USGS Great Lakes Science Center, [3]Bay Mills Indian Community.
Challenges and Successes in Building Reciprocal Relationships: Creating an Ethical Space to Study Adikameg.

Exposure to damaging ultraviolet radiation (UV) could impact the early life stages of Adikameg (Lake Whitefish), an economically and culturally important fishery. With the help of collaborators, we are investigating the role of UV in regulating recruitment of Adikameg in the Great Lakes using Two-Eyed Seeing (*Etuaptmumk* in Mi'kmaw) as a guiding framework, which combines the strengths of both Indigenous and Western ways of knowing. Using this approach, we are intentionally emphasizing the process of creating an ethical space where there are shared goals, a focus on place-based research, and a mutual respect of Indigenous partners. During annual meetings and smaller group gatherings, we have fostered place-based research by providing opportunities for our 40 collaborators from 17 organizations to reflect on their connection to the Great Lakes, express gratitude for their sites and study organisms, and develop ways to practice reciprocity. Conversations stemming from our relationships with Indigenous partners as well as our connections with coregonines led to novel observations of UV-induced hatching. With the help of mentors, we have identified ways to further develop an ethical space, such as co-developing research questions or adapting current research questions to reflect the interests of the community. By focusing on seeing through both Indigenous and Western lenses, we gain a more holistic view of Adikameg and the Great Lakes, and we can build on these relationships to find ways to practice reciprocity.

Margaret Owensby[1], Chris Massey[1], Madison Yawn[1], Norberto Nadal-Caraballo[1], Michael Padilla[2], Johnna Potthoff[2] and Kaitlyn McClain[2], [1]U.S. Army Corps of Engineers, Engineer Research and Development Center, Coastal and Hydraulics Laboratory, [2]U.S. Army Corps of Engineers, Chicago District. **An Overview of Storm Surge and Wave Hazards Modeling and Statistics within the Framework for Resilient Great Lakes Restoration Initiative (GLRI) Investments Study.**

A multi-agency team composed of the U.S. Army Corps of Engineers (USACE), the National Oceanic and Atmospheric Administration's Great Lakes Environmental Research Laboratory (NOAA-GLERL), the U.S. Geological Survey (USGS), the Environmental Protection Agency (EPA), the Federal Emergency Management Agency (FEMA), and various state stakeholders is currently engaged in a regional-scale, multi-year study called the Framework for Resilient Great Lakes Restoration Initiative (GLRI) Investments. This effort will identify the expected range of future water levels, wave heights, and ice conditions for each of the Great Lakes and Lake St. Clair. A distribution of future static lake levels and ice cover conditions for each lake is determined by considering future changes in temperature and precipitation to calculate anticipated runoff, evapotranspiration, and ice coverage conditions. Coupled ADCIRC and SWAN models are employed to characterize resulting surge and wave responses for representative extreme storm conditions. Probabilistic hazards analysis of model results is conducted to calculate the distribution of future total water levels and wave heights for each lake. The resulting statistics and model results will be made publicly available through USACE's Coastal Hazards System and are used to assess flood risk, provide guidance for future projects, and promote coastal resiliency. This presentation will provide a general overview of the entire project and will discuss the utility of modeling products and statistics produced by this study for researchers and practitioners in the Great Lakes.

Shubhashini Oza, Brown and Caldwell. **PFAS in biosolids and comparison on interlaboratory detection limits.**

The USEPA 2021 - 2024 Strategic Plan calls for finalizing a risk assessment for PFOA and PFOS in biosolids by winter 2024, paving the way for future rulemaking. In context of this ongoing effort, the USEPA recently funded four research teams nearly $6M to support states, municipalities, and utilities in determining the potential risk from pollutants found in biosolids. Results from this research will be used to inform the development of standards and policies for biosolids management. One among the four funded projects is led by the Michigan State University, in collaboration with the Colorado State University, the University of Georgia, and the Great Lakes Water Authority and focuses on PFAS in biosolids. Around 27 wastewater facilities across the nation were sampled for biosolids and evaluated for PFAS (40 compounds) as per EPA Method 537.1 (modified and Draft Method 1633. The initial findings of this surveillance study will be presented.

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Kimberly Panozzo, Ishfaq Rahman and Kevin Czakowski, University of Toledo. **High-Resolution Mapping of Agricultural Practices in the Maumee Watershed.**

In 2021, researchers at the University of Toledo (UT) and The Ohio State University (OSU) began work on a two-year collaboration aimed at guiding the H2Ohio program with projections of conservation practice effectiveness in the Maumee River watershed. The overarching goal of this work was to simulate water quality benefits expected from recent and future adoption of the 'top ten' H2Ohio practices using field-to-watershed scale geospatial analysis and improvements to hydrologic modeling (SWAT). The team at UT used over 15 years of collected *in situ* agricultural field ground truth data, high resolution open-source imagery, and innovations in remote sensing technology to map agricultural practices throughout the Maumee Watershed. High-resolution (<1 meter) RS imagery was used to define field units and lower-resolution satellite imagery (Sentinel-2 & Landsat) to derive practices for a baseline period (2008), pre-H2Ohio (2017), and post-H2Ohio (2022). Three time periods were mapped to identify field boundaries and assess the goodness-of-fit between the high-resolution observations and low-resolution RS outputs. The field units, fused with standardized owner parcel data, was joined with *in situ* ground truth and used to classify agricultural practices using RS classification methods. Agricultural practices identified include field-scale tillage, yearly arable/non-arable acres, crop types, rotation patterns, cover crops and filter strips. The results, aggregated to larger units for incorporation into SWAT modeling, are further evaluated using spatial analysis to improve our understanding of agricultural practices in the watershed.

Gabrielle Parent-Doliner, Water Rangers. **The Business Case for Investment in Community Based Water Monitoring Toolkit.**

Water Rangers, along with the National Community-based Water Monitoring Collaborative (the "Collaborative"), developed a business case toolkit as a way to support Community Based Water Monitoring (CBWM) groups in securing long-term, core funding for their activities to protect water at the scale that matters to each of us. Join us as we introduce this *Case for Investment in CBWM Toolkit* as the single most beneficial collaborative project to address the chronic underfunding Community-based Water Monitoring groups face across the country. The toolkit aims to equip local CBWM groups with tools to effectively calculate and communicate their program's value and garner more robust support and financial investments. The *Case for Investment in CBWM Toolkit* includes 15

tools to this end, including everything from a program and data quality and value calculator, measure and protocol guides, and tools for grant writing, cost analysis, benchmarking, swing-weighting, transitioning from ranking to relative weight, attribution, and index.

James Pauer[1], Wilson Melendez[2], Kelsey Vitense[1], Lisa Lowe[3], Terri Jicha[1], Tom Hollenhorst[1] and Bridget Beyer[4], [1]US EPA, Office of Research and Development, [2]General Dynamics Information Technology, [3]North Carolina State University, [4]ORAU NSSC. **Modeling Harmful Algal Blooms: Transparency, baby steps and patience are required.**

Cyanobacteria Harmful Algal Blooms (CyanoHABs) are a major concern in waterbodies across the United States and a growing concern in the Great Lakes. In Lake Erie these blooms have severely impaired recreational and drinking water usage. Models can be useful tools to make predictions and understand the drivers of CyanoHABs in the Great Lakes. However, a lack of understanding of the biogeochemistry and insufficient measurements of CyanoHABs and related processes makes it difficult to formulate credible model equations. In Lake Erie, researchers have developed a range of models, using relatively simple to more complex formulations which in some cases relied on outdated assumptions and poorly constrained model coefficient values and processes. We propose a simple approach based on what we have learned from previous modeling efforts in the Great Lakes and from on-going field and lab experiments. Using machine learning models, we will explore novel approaches linking our results to derive critical underlying mechanisms and driving mechanics behind the establishment, spread and peak of cyanobacterial blooms in the Great Lakes. Early results show the importance of circulation patterns and phosphorus loadings on the western basin phosphorus concentrations (an important CyanoHABs driver), while phytoplankton settling (including the CyanoHABs) can have a significant impact of the central and eastern basins. Here we will show results comparing our model to other CyanoHABs models and point out strengths and weaknesses of different model approaches.

Pranesh Paul[1], Ramesh Rudra[1], Pradeep Goel[2] and Prasad Daggupati[1], [1]University of Guelph, [2]Ontario Ministry of the Environment, Conservation and Parks. **A Framework to Setup a Comprehensive Large-Scale Model for the Canadian Lake Erie Basin.**

Evaluating the impact of various land use and land management scenarios on sediment and phosphorus loads in the Canadian Lake Erie Basin represents a focused and innovative research approach. Employing the Soil and Water Assessment Tool (SWAT), we configured the model to encompass 290 sub-basins within the Lake Erie basin, relying on information sourced from multiple conservation authorities. Our dataset incorporates comprehensive land use and land cover information, including major crop rotation details, complemented by intricate land management inputs, which were organized on a county-wise basis due to the unavailability of field-scale data. Additionally, as many rivers are regulated, our model accounts for ten primary reservoirs within its setup. To generate observed data for sediment and phosphorus, we applied the well-established Weighted Regressions on Time, Discharge, and Seasonal (WRTDS-K) technique to grab sampled information (using HYDAT and PWQMN data). Subsequently, the model underwent calibration and validation using the R-SWAT calibration tool, focusing on streamflow, sediment, and phosphorus across various monitoring stations within the basin (using HYDAT and PWQMN data). Post-calibration, the simulated values closely mirrored the observed data patterns, falling within satisfactory limits. A comprehensive presentation of the detailed results and analysis from this study will be delivered at the upcoming conference. The main purpose of the detailed modelling framework is to identify critical zones in the Canadian Lake Erie basin for implementing best management practices.

Isabelle Paulsen[1] and J. Stuart Carlton[1, 2], [1]Purdue University, [2]Illinois-Indiana Sea Grant.
Exploring New Pathways: Teachers' and Culinary Market's Attitudes Towards Invasive Crayfish.

Invasive crayfish in the Great Lakes Region pose a threat to local ecosystems as they often outcompete their native counterparts. Native crayfish are important consumers and predators within the food web and the disruption that invasive species cause can have wide-reaching affects. Much research and outreach has been done about the spread of invasive crayfish by use as bait by recreational boaters, use in aquariums and the pet trade, and through aquaculture. This talk explores an additional two potential introduction pathways: teachers who might use crayfish in the classroom, and the culinary market who use them as live food products. Both of these groups have been noted as potential pathways for crayfish introduction and spread, however there is little understanding of the attitudes and behaviors towards crayfish within these groups. We will discuss what work has been done to understand these groups, gaps that exist within it, and next steps to learn more about their attitudes, behaviors, and outreach needs. This work will help outreach professionals across the Great Lakes Region better understand these potential pathways and their outreach and education needs to help prevent further introductions.

Kristen Pearce, Elizabeth Spitzer, Liane Rosario, Steve Brown and Robin Mattheus, Illinois State Geological Survey. **Topobathymetric monitoring to study breakwater impacts at Illinois Beach State Park, SW Lake Michigan.**

Lake Michigan beach shorelines are dynamic and evolve with storm events, seasonal to decadal lake-level changes, and impacts of winter-ice. Shoreline and nearshore areas are the most dynamic, and logistically difficult part of the coastal system to monitor. Geomorphic changes at Illinois Beach State Park are captured by an expanding Illinois State Geological Survey (ISGS) topobathymetric monitoring dataset from monthly to seasonal surveys since 2018. This one-of-a-kind data coverage, funded by the Illinois Department of Natural Resources' Coastal Management Program, will help inform managers on the impacts and efficacy of different types of recently emplaced shoreline-protection structures. Our dataset, which combines drone-based topographic and sonar-based bathymetric records, should help answer the following questions: (1) How are newly emplaced offshore structures interacting with lake hydrodynamics (e.g., to modify nearshore waves and currents)? And (2) What are the impacts thereof on beach geomorphology? We resolve nearshore bar dynamics and shoreline-change patterns in the pre-construction dataset that relate to changes in lake-level. Preliminary findings also suggest that different shoreline sections tend to exhibit different geomorphic behaviors in response to lake-level change due to (1) the presence of shoreline infrastructure, and (2) time-varying alongshore sand-transport dynamics. Ongoing analyses and data collection efforts will expand upon these insights, addressing changes to the system related to breakwater construction.

Thomas Pendergast, Ryan Mulligan, Leon Boegman and Jason Olsthoorn, Department of Civil Engineering, Queen's University. **Data-Driven Eddy Diffusivity Parameterization for Vertical Mixing.**

Thermal stratification, which has very important consequences for vertical mixing of tracers, can be analyzed using vertical temperature profile measurements. The evolution of the thermal stratification T (z, t) is often modelled as a one-dimensional process obeying a diffusion equation, for an eddy diffusivity k_e, assuming a fixed cross-sectional area. The value of k_e is often estimated through empirical formulae. We propose a data-driven method to determine the optimal k_e as a function of depth and time directly from the temperature profile data. Using an adjoint-loop, we can

determine the forcing function F (z, t) that minimizes the error between the diffusion equation and the observed data. The adjoint-solver updates F within each iteration using the gradient of the Lagrangian adjoint variable to minimize the error between the observed and simulated data. From this forcing term we can determine the eddy diffusivity as a function of depth and time. The method developed has been used on laboratory data analyzing double diffusive salt fluxes and on temperature profiles from model and field data in Canadian Lakes. The adjoint-solver has converged reasonably well for both data sets thus far. Our hope is that this method may provide a more accurate estimation of eddy diffusivity for spatially and temporally varying mixing processes in comparison to the simplifying assumption of a constant k_e.

Michael Penka and Suzanne Gray, The Ohio State University. **Effects of Turbidity on Reaction Distance of Smallmouth Bass to Fishing Lures of Different Colors.**

Lake Erie is regularly experiencing massive changes in water quality that may affect commercially and recreationally important fish populations. Increases in turbidity result from summer algal blooms and meteorological events such as storms and wave movement that stir up sediments from the lake bottom. Algal and sedimentary turbidity both decrease light penetration, but algal turbidity leaves water with a green coloration, while sedimentary turbidity has no substantial effect on water coloration. Smallmouth Bass (*Micropterus dolomieu)* are an economically important species in the Lake Erie sport fishing industry and are visual predators. Turbidity increases can substantially impact visual sensitivity in Smallmouth Bass, potentially impacting Smallmouth Bass's interactions with fishing lures. I studied the effects of algal and sedimentary turbidity on the reaction distance of Smallmouth Bass to lures of two common colors, black and gold, through experiments using wild-caught Smallmouth Bass in a controlled laboratory setting at Ohio State's F.T. Stone Laboratory. Preliminary data analysis suggests that the algal turbidity treatment resulted in the greatest reduction in reaction distance, followed closely by the sedimentary turbidity treatment. Both turbidity treatments were shown to reduce reaction distance to near half or less than half of the clear water reaction distance. There does not appear to be any major difference in reaction distance between the gold and black lures within treatment groups, although statistical tests for significance have not yet been conducted.

Christopher Pennuto and Kira Yerofeev, Buffalo State University. **Snails behaving badly: an example of maladaptive behavioral responses to non-native predators.**

Snails exhibit predation defenses ranging from morphological changes to behavioral responses when faced with native predators, and those responses are mediated by predator type. Previous work suggests they are particularly vulnerable to predation by non-native round goby in newly colonized habitats. We investigated the plasticity of behavioral responses by determining if predator foraging domain (pelagic or benthic) was as important as predator identity (native or non-native) or taxonomic group (fish vs crayfish) using kairomone trials in the lab and a field mesocosm experiment. In the lab, snails avoided different predator kairomones differently over 2-hours of exposure, though responses to conspecific alarm cues and fish were strongest and almost always crawl-out behavior. In the mesocosm, snails exhibited strong crawl-out responses to crayfish and had high survival whereas snails were eliminated by round gobies within 3 days of starting the experiment. These data suggest native physid snails employed some initial behavioral avoidance when exposed to kairomones of both native and non-native predators, but were too slow to respond to non-native round goby predation in outdoor mesocosms. Thus, native populations of physid snail would seem vulnerable to new introductions of round goby in tributary streams.

Kelly Peterson, Haley Hoehn and Laura Johnson, Heidelberg University. **What Mud Can Do for You: Soil Removal of Phosphorus from H2Ohio Wetlands.**

The H2Ohio program is aimed at reducing excess nutrient loading, mainly phosphorus (P), to Lake Erie, through the restoration of wetlands. Due to the variable characteristics of wetlands, the efficiency of wetlands to store phosphorus is highly variable. This study examined the potential for wetland soils to remove P from water across seven H2Ohio wetlands. Within each site, soil cores (5 cm depth) were collected from pools subdivided into habitat types; open water, water with high vegetation, the edge of the pools, and wet meadows. These habitats varied in vegetation level, inundation, organic matter, and pH. Phosphorus sorption and water extractable P (WEP) of soil samples was measured using standard methods. We then calculated the capacity of soil to sorb P from the water column. These measurements were compared to soil pH, percent organic matter, percent moisture, nitrogen, and carbon. We found the open water and vegetated habitats absorbed the most P, while the edge and wet meadow habitats had the highest WEP. Of the fifty soils samples collected, only one released P, the rest were highly sorptive. We found a significant correlation between the amount of P sorbed and percent organic matter as well as percent water weight. Overall, newly restored wetlands have the potential to exhibit high removal of P from surface water and contribute to the effort of reducing watershed loads of P.

Sarah Peterson and Chin Wu, University of Wisconsin-Madison. **Coastal geomorphological changes near groin structures under water level fluctuations in Lake Michigan.**

Coastal geomorphological changes to shorelines, beaches, and bluffs are closely related to ecosystem health and coastal management in the Laurentian Great Lakes. Groins, shore-perpendicular coastal protection structures are commonly implemented in the Great Lakes to trap sediments and preserve the integrity of beaches. However, groins can also have undesirable coastal geomorphological changes, such as sediment accumulation updrift and sediment deprivation and erosion downdrift of groins. In recent years, extreme water level fluctuations in Lake Michigan (from 175.57m in 2013 to 177.5m in 2020 - IGLD 85) have been found to greatly impact the coastal environment. Nevertheless, no studies have addressed how coastal geomorphological changes near groin structures vary under extreme water level fluctuations in the Great Lakes. In this talk, we will report changes to shorelines, beaches, and bluffs adjacent to and within groins and groin series at Sheridan Park, Wisconsin, on Lake Michigan's coast under varying water level fluctuations, as an example. Possible causes and implications of these coastal geomorphological changes will be discussed as well. Results provide insights to guide coastal design, planning, and management in the Great Lakes.

Sally Petrella[1], Lauren Eaton[1], Susan Thompson[2] and Samantha Davis[1], [1]Friends of the Rouge, [2]Wayne County Department of Public Service. **Collaboration between Watershed Group and Regulatory Agency Key to Addressing Toxic Substances.**

An ever-growing number of contaminants threaten our lakes and streams yet the agencies charged with regulating them often do not have the staffing or capacity to do so. Watershed groups, with their strong relationships with local communities and ability to train and mobilize volunteers are uniquely positioned to assist in this work. The non-profit organization Friends of the Rouge (FOTR) began monitoring the Rouge River watershed for chloride in 2020 by training volunteers to use simple test strips. The State of Michigan had just set water quality standards for chloride and sulfate so FOTR began sharing their results with the state. The state was very interested in the data and in 2023 funded FOTR to expand their chloride monitoring. This included collecting required samples to officially list a waterbody as well comparing different methods that could be used by

other volunteer groups. The work will lead to recommendations for other watershed groups as well as assisting the state in identifying impaired bodies of water. It also entails using ArcGIS Collector apps for data collection and submission to the STORET database. FOTR has also assisted several projects examining PFAS in fish by utilizing local anglers and simple seining techniques to collect the fish. Collaborations like this are key to responding to climate change and the challenges it poses by capitalizing on local resources.

Robbie Pharr, Jefferson-Chalmers WATER Project. **Youth Scientists Step-In for Government Failures.**

Impacted by a combined sewage discharge into Fox Creek, a tributary of the Detroit River, residents organized to secure private funds to sample and test the water quality because public agencies were not. Working with local educators, Youth Scientists from the area were recruited to aid in collection and analysis and the program has expanded to document the ecosystem in one of the neighborhood's riverfront parks. The Program not only engages future scientists, providing first-hand experience, but notifies the community of surrounding water quality. Learn about the program concept, recruitment efforts and success of the program as well as lessons learned. The Jefferson-Chalmers WATER Project is a community-based, community-driven and community-supported initiative to find solutions to the interconnected water resource management challenges in the neighborhood. The initiative has three goals: Keep Sewage out of Basements & Canals, Keep Stormwater out of the System and Keep Great Lakes out of the Neighborhood. Surrounded by natural and enclosed water assets on Detroit's eastside, creating sustainable solutions in overcoming these challenges are tantamount to creating a vibrant place where people live, work, play and find refuge.

Joshua Pickering and Rebecca Rooney, University of Waterloo. **Spatio-temporal changes of a breeding bird community over 30 years at Long Point, Ontario, Canada.**

Habitat loss and degradation - driven by ecological disturbance - is the leading cause of global avian population decline, yet there are few studies which have the opportunity to evaluate the long-term response of bird communities following the removal of large-scale disturbance. We take advantage of a long-term community monitoring project at Long Point, Ontario, Canada to investigate changes in breeding bird community diversity, density, and composition during a 30-year period of white-tailed deer suppression. In North America, overabundant deer have been shown to be an indirect but key driver of bird decline by reducing the structure and altering the composition of vegetation communities, which in-turn limits the availability of food resources and nesting opportunities for birds. Still, deer management is not the only factor influencing breeding bird community changes at Long Point, and the complex interactions of invasive species expansion, local climactic fluctuations, and Great Lakes' water level instability present an opportunity to investigate these additional and cumulative effects on the bird community. We employ time series, generalized linear mixed models, and non-metric multidimensional scaling models in addition to a model competition framework to show regeneration of the breeding bird community at Long Point. Our results are anticipated to support local conservation management as well as regional and national avian community recovery and deer management efforts.

Emma Pierce[1], Zachary Steffensmeier[2] and Suzanne Gray[2], [1]The Ohio State University F.T. Stone Laboratory, [2]The Ohio State University. **Testing Round Goby (*Neogobius melanostomus*) boldness and foraging in multiple turbidity and predator conditions.**

Vision is an important sense in fishes, as many behaviors are mediated by visual cues. Turbidity distorts vision underwater, with suspended particles affecting the visual environment. Sedimentary and algal particles are known to impact fish visual thresholds in Lake Erie, therefore we expect behavioral shifts associated with increased turbidity. Boldness, or the speed at which something new is explored, is a specific behavior in fishes. Previous studies show that a consistent environment favors boldness within populations. However, it is unknown if fluctuating environments favor plasticity in individual boldness. We aimed to determine: 1) the effect of turbidity type (clear, sedimentary, algal) on boldness and foraging, and 2) the effect of predator presence on boldness and foraging in the invasive Round Goby (*Neogobius melanostomus*). Round Goby in Lake Erie have a complex relationship with a native predator, Smallmouth Bass (*Micropterus dolomieu*). We hypothesized Round Goby boldness will be higher with increased turbidity, while the presence of Smallmouth Bass would decrease boldness. We found that the interaction between turbidity and predator presence was significant, meaning that as turbidity increased, the effect of the predator visual cue decreased. The interaction between turbidity type and predator presence was significant for foraging behavior. As turbidity type changed, the impact of predator presence on foraging behavior changed significantly. We concluded that turbidity impacts Round Goby vision, predator risk assessment, and foraging.

Mike Piskur, Great Lakes St. Lawrence Governors & Premiers. **Great Lakes St. Lawrence Trees Initiative.**

The Great Lakes St. Lawrence Governors & Premiers are leading a regional effort with the goal of planting 250 million trees by 2033. Over the next decade, GSGP will work with the region's eight US States and two Canadian Provinces, federal governments, corporations, cities and other institutions to achieve this goal. Tree planting creates a multitude of benefits for the region's environment, economy and people. These benefits include carbon storage, water quality improvements, habitat, health and recreational access. The region's States and Provinces will collaborate and support one another and other entities to reach their tree planting goals. This will include identifying and developing strategies and policies to maximize tree planting benefits and the "return on investment." This presentation will discuss obstacles, opportunities, and potential innovations to scale tree planting across the region.

James Polidori[1], Hannah Paulson[2] and Drew Gronewold[3], [1]Great Lakes Commission, [2]Wisconsin Department of Administration, [3]University of Michigan, School for Environment and Sustainability. **Understanding Great Lakes water use trends to support sustainable water resource management.**

Current and projected impacts of a changing climate on the Great Lakes basin present a sizeable challenge to protecting our precious water resources. To ensure their sustainable use and conservation, it is more important than ever to understand water use trends and how they may influence the regional water balance. In 1987, the Great Lakes Charter called for the creation of a Water Resources Management Committee, which found that reliable water use data will improve forecasting of regional water needs, consequences of diversions, and cumulative consumptive uses. Since that time, the Great Lakes Commission has served as the repository for the Great Lakes Regional Water Use Database, a collaborative regional effort to improve data quality, promote sustainable water management, and guide the future development of our water resources. To better

understand water use at a more localized scale, the Conference of Great Lakes-St. Lawrence Governors and Premiers supported a study to assess municipal water use trends from 1998-2018. The University of Michigan researchers analyzed a suite of socioeconomic variables to find potential drivers behind the generally decreasing residential water use trends over this time period. Utilizing the Commission's Water Use Database and supporting further research to establish a clearer understanding of water use trends at both the regional and municipal scale is critical as the Great Lakes region looks toward a future of increasingly variable water supplies.

Alexis Porter[1], Brian Scull[1], Brendan May[1], Charlyn Partridge[1], Susan Peters[2], Shannon Briggs[3] and Ryan Otter[1], [1]Annis Water Resources Institute, Grand Valley State University, [2]Emerging & Zoonotic Infectious Diseases Section, Michigan Department of Health & Human Services, [3]Water Resources Division, Michigan Department of Environment, Great Lakes, and Energy. **MiNet: A Michigan collaboration of 25 labs/partners working together to assess recreational beaches and wastewater.**

Michigan Network for Environmental Health & Technology (MiNet) is a statewide network of laboratories and state partners focused on the use of advanced polymerase chain reaction (PCR) based methods to assess recreational water quality, identify sources of fecal contamination in surface water, and monitor SARS-CoV-2 in wastewater. The network provides timely data to local health departments, utilities, and state and tribal partners to better protect human health. In this presentation the structure, communication, and data sharing strategies of the Network are demonstrated through a series of case examples. These examples will be presented from the lens of a member laboratory, the Annis Water Resources Institute (AWRI) at Grand Valley State University. Case example 1: Since November of 2020, AWRI alone has processed and reported on 3,434 SARS-CoV-2 wastewater samples, working to not only communicate disease dynamics with partners, but advance the science of understanding variant tracking and COVID-19 disease within the west Michigan population. Case example 2: AWRI has been monitoring beaches for over 20 years, with recent years dedicated to advancing molecular methods (qPCR) for rapid identification of contaminants. Case example 3: Across MiNET, including AWRI, there is a focus on determining the root causes of *E. coli* contamination at inland lake and Lake Michigan beaches using droplet digital PCR and microbial source tracking.

Cameron Proctor, University of Windsor. **Spatial and Temporal Trends in Greenhouse Plant Physiology.**

Greenhouses alter the physical environment to improve plant growth conditions, but microclimates can still develop causing plant physiology to deviate from normal. Using a high-throughput fluorometer/porometer (e.g., LICOR LI-600f) cucumber physiology was surveyed over an entire greenhouse bay (~10 acres) at ~88 sites on a monthly time-interval. Microclimate differences in temperature were primarily along the heating rails (up to a 0.15 degree difference), while illumination was two times greater between the top and bottom leaves (~90 to 265 umol/m2/s1), despite the leafy vine section being less than a meter tall. Environmental changes such as rain had a considerable change in internal temperature (~two degrees) and humidity conditions, resulting in 40% decrease in stomatal conductance (mol H20/m2/s) and a 12% decrease in maximum fluorosense. The greatest difference between actual and maximum chlorophyll fluorosense occurred in the lowest leaves which received the least amount of light. As the physical infrastructure in a greenhouse (e.g., lighting, heating lines, etc.) is largely immobile, growers could optimize plant positioning and pruning to increase efficiency in light conversion. Comparison of

different bays with LED and LED+sodium lamps did reveal considerable differences in electron transport rate (umol/m2/s), although the LED+sodium lights had higher PhiPH2 effeciency.

Cameron Proctor and Calvin Love, University of Windsor. **The Advancement of Minirhizotrons for Precision Farming.**

Solving the 4R (Right source, Right Rate, Right Time, Right Place) fertilizer puzzle in agriculture has historically proven difficult, principally from a lack of data on the traits of the main plant organelle responsible for nutrient uptake, roots. Substantial variation exists in crops for an array of root phenotypes that improve nitrogen capture, yet uptake promoting root traits are not always expressed in the field. Crop roots respond differently than shoots to environmental factors and have considerable plasticity to adapt to localized conditions. Automated minirhizotrons paired with drone remote sensing are a new approach to equip farmers with spatial tools to manage fertilizer inputs. With tandem above and belowground imaging, allometric relationships can be developed, and the controlling factors that influence root system architecture in the field can be elucidated. The effects of fertilizer treatments (i.e., broadcast, deep placement, y-band) mimicked in the lab on root traits over time quantified through automated minirhizotrons will be presented. The challenges of field scale environmental mapping at high sensor density will be discussed as well as future possibilities of integrating automated minirhizotrons into farming operations and their utility for developing fertilizer best management practices.

Ge Pu[1], Kirill Shchapov[2], Nolan Pearce[3], Ted Ozersky[2] and Great Lakes Winter Grab Research Consortium[4], [1]Cleveland Water Alliance, [2]Large Lakes Observatory, University of Minnesota Duluth, [3]Trent University, [4]Consortium. **The Great Lakes Winter Grab: Limnological Data from a Multi-Institutional Winter Sampling Campaign.**

Interest in winter limnology is growing rapidly, but there is a shortage of standardized multivariate datasets on winter conditions. We present the results of a multi-institutional winter sampling campaign conducted across all five of the Laurentian Great Lakes (the Great Lakes Winter Grab). The objective of Winter Grab was to characterize mid-winter limnological conditions in the Great Lakes using standard sample collection and analysis methods. Nineteen research groups sampled 49 locations varying widely in depth and trophic status, collecting a range of limnological data. This dataset includes observations on ice and snow properties, water column physical parameters, diverse biogeochemical observations, data on plankton communities, and bacterial and primary production rate measurements. This dataset can be used to examine diverse aspects of the Great Lakes ecosystem or be integrated with winter observations from other lakes in order to improve understanding of winter limnology across different aquatic systems.

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Baozhu Zhang[1], Weiguang Wang[1], Fanyi Wang[1], Xiaolan Chen[2], Lijuan Zhou[3] and **Yu Qian**[1], [1]School of Ecology and Environmental Sciences, Yunnan University, [2]School of Life Sciences, Yunnan University, [3]College of Agriculture and Life Sciences, Kunming University. **Exudate of *Microcystis* aeruginosa change root development by impacting plant hormone synthesis and auxin signal transduction.**

Microcystis aeruginosa (*M. aeruginosa*) is one of the typical cyanobacterial species observed in algae blooms. We explored the effects of *M. aeruginosa* on root development by exposing model species *Arabidopsis thaliana* (*A. thaliana*) to the exudate of *M. aeruginosa* (MaE). Results showed that

the lateral root primordium development significantly advanced. The number and length of the lateral root significantly increased, and the length of the primary root significantly decreased in the MaE-treated group. High-throughput target profiling analysis of the treated 7 days seedlings root showed the concentration of cytokinin family compound significantly decreased in the MaE group, while the concentration of salicylic acid and N-(jasmonoyl)-S-isoleucine significantly increased compared to the control. Transcriptomics analysis revealed that both the synthesis and the metabolism process of the above four hormones were impacted by MaE treatment. Activation of the auxin signaling transduction pathway was observed based on the expression level of key proteins in auxin signal transduction regulation. No significant difference in DII expression level was observed between the two groups, the expression of DR5 and ARF7 were promoted by MaE treatment in both lateral root primordium and primary root tip. The above results indicated that MaE can affect the development of higher plant root system architecture by altering plant hormone balance and auxin signal transduction process.

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Melika RahimiMovaghar[1], Mohammad Reza Najafi[1], Arezoo RafieeiNasab[2], Rajesh R. Shrestha[3] and Yongbo Liu[3], [1]Department of Civil and Environmental Engineering, Western University, [2]Research Application Laboratory, National Center for Atmospheric Research, [3]Watershed Hydrology and Ecology Research Devision, Environment and Climate Change Canada.
Characterizing Successive Dry-Wet and Wet-Dry Extremes in the Great Lakes Basin under Climate Change.

The risk associated with hydroclimatic hazards, particularly successive dry-wet (SDW) and wet-dry (SWD) extremes, is expected to change under a warming climate. In this study, we aim to characterize these effects over the Great Lakes (GL) basin, one of the most populated regions in North America with significant freshwater demand. To assess the impact of climate change on these successive extremes in the basin, a set of five variables (maximum and minimum temperatures, precipitation, and wind speed in the north and east directions) from eight CMIP6 GCMs under SSP 585 scenarios were statistically downscaled/bias corrected using the Multivariate Bias Correction algorithm (MBCn) and used as input to the calibrated and regionalized WRF-Hydro model. The study then applies the standardized runoff index (SRI) to explore the behaviour of SDW and SWD extremes based on WRF-Hydro simulations for the historical period (1985-2014) and future projections (2071-2100). Fixed 10^{th} and 90^{th} quantile thresholds are employed on the simulated runoff to calculate characteristics of SDW and SWD extremes, including frequency, intensity, and transition time over the GL basin. Projections indicate future increases in the frequency and intensity of both SDW and SWD extremes over almost all regions within the GL basin and decreases in their transition time. Overall, this study highlights the potential hydroclimatic hazards over the GL basin and provides valuable insights for future planning and adaptation strategies.

Riley Ralph[1], Justin Chaffin[2], Hans Paerl[3] and Christopher Ward[1], [1]Bowling Green State University, [2]Ohio State University, [3]UNC Institute of Marine Sciences. **Effects of nutrient manipulations on Lake Erie microbial community composition and toxigenic *Microcystis* abundance.**

Freshwater cyanobacterial harmful algal blooms (cHABs) are a major concern in the western basin of Lake Erie due to toxin contamination of recreational and drinking waters and their associated risks to humans and wildlife. Anthropogenic nutrient pollution is the primary culprit in facilitating cHAB blooms, warranting the International Joint Commission's recommendation for a

40% reduction in annual phosphorus loading into Lake Erie by 2025. Yet recent studies have indicated that higher nitrogen-to-phosphorus ratios can favor toxigenic *Microcystis* strains over non-toxigenic ones, motivating further research on the outcomes of phosphorus only vs. dual nitrogen and phosphorus reductions. Using an in-lake microcosm setup to manipulate nutrient levels of Lake Erie water samples, we examined plankton responses to various dilutions of N and/or P over three-day incubation periods in early and late summer of 2022 and 2023. DNA extracted from vacuum-filtered water samples was used for quantitative PCR for quantifying gene copy numbers of *Microcystis* 16S rDNA and the *Microcystis*-specific MC toxin synthetase gene *mcyD*. Additionally, we performed amplicon sequencing of 16S rRNA genes to characterize changes in microbial community composition between treatments. We present on our findings to provide greater predictive insight into how stepwise nutrient dilutions may affect Lake Erie *Microcystis* abundance and toxigenicity and microbial community composition.

Euan Reavie[1], Katya Kovalenko[1], Meijun Cai[1], Elizabeth Alexson[1], Holly Wellard Kelly[1] and Anne Scofield[2], [1]Natural Resources Research Institute, University of Minnesota Duluth, [2]USEPA-GLNPO. **Great Lakes phytoplankton are changing in many ways and for many reasons.**

As a significant freshwater resource, we must consider the implications of changes at the base of the Laurentian Great Lakes food web. Those responsible for tracking and maintaining ecosystem services on the Great Lakes are concerned about the ecological trajectories of the lakes, and phytoplankton data provide an early warning tool to uncover impacts. Phytoplankton are sensitive to environmental changes because of their high turnover rate and direct, rapid response to changes in water quality. Monitoring of phytoplankton reveal changes in all lakes in both pelagic and nearshore environments, and on short (decadal) and long (centennial) timescales. Drivers include invasive mussels, nutrients, and climate change. Familiar changes include eutrophication and oligotrophication, the latter owing to invasive mussels. After accumulating two decades of phytoplankton monitoring data, several patterns emerge: unicellular flagellated algae are increasing in relative abundance; the substantial loss of phytoplankton biomass due to the quagga mussel invasion in lakes Michigan and Huron may be showing signs of stabilization; and densities of cyanophytes are increasing. Atmospheric warming, which is changing lake physical characteristics such as stratification, also appears to be a driver of phytoplankton community reorganization. Also, there are definable cliques of taxa that likely reflect alliances or antagonistic relationships and may be further driven by bottom-up processes that define seasonal phytoplankton community structure. We will discuss possible implications of climate, nutrients and invasive species drivers on these changes.

Breanna Redford, Chippewas of Nawash Unceded First Nation. **A Saugeen Ojibway Nation methodology for applying Saugeen Ojibway knowledge in dikameg (*Coregonus clupeaformis*) research.**

There is still a great deal of hesitation and uncertainty in western science on partnerships with Indigenous Nations, due in part with misunderstandings of the methodological approaches used for Indigenous Knowledge systems. As part of a broader Two-Eyed Seeing approach to research, the Saugeen Ojibway Nation (Chippewas of Nawash Unceded First Nation and Chippewas of Saugeen First Nation collectively) have developed their own methodology for applying Saugeen Ojibway Nation knowledge within the Nation's Fisheries research program. Using dikameg (*Coregonus clupeaformis*) in Lake Huron as a case study, this presentation will include a high-level description of study design from inception to analysis and communication of results. By providing this case study it is the intention of the authors to provide a path for other researchers and Indigenous Nations to embark on in their own research initiatives.

Breanna Redford[1], **Kaitlin Almack**[2], **Ryan Lauzon**[1], **Erin Dunlop**[3] and **Alexander Duncan**[4], [1]Chippewas of Nawash Unceded First Nation, [2]The Nature Conservancy, [3]Ministry of Natural Resources and Forestry, [4] Centre for Indigenous Fisheries, University of British Columbia. **The gift of multiple knowledges.**

The Saugeen Ojibway Nation (SON; Chippewas of Nawash Unceded First Nation and Chippewas of Saugeen First Nation, collectively) and Ontario Ministry of Natural Resources and Forestry (MNRF) collectively govern the commercial fishery within the SON's traditional territory located in Lake Huron's main basin and Georgian bay of the Laurentian Great Lakes. Plagued by a history of conflict, the two groups often operated in seperate silos with external facilitated communication, which contributed to a sense of mistrust regarding the legitimacy of science being used to inform decisions. Only through the adoption of the Two-Eyed Seeing (*Etuaptmumk* in Mi'kmaw) approach by MNRF and SON in joint research on fishery-related concerns were strides made in building a trusting partnership. This session will explore how Two-Eyed Seeing can be implemented in early stages of co-developed projects to foster relationship-building between government agencies and First Nations. Our case study will focus on a co-developed research proposal involving the role lake trout (namegos; *Salvelinus namaycush*) have had in recent declines in lake whitefish (dikameg; *Coregonus clupeaformis*) abundance in Lake Huron. The benefits and challenges associated with cross-cultural collaboration will be discussed, with emphasis placed on how the Two-Eyed Seeing approach is foundational for ensuring equitable partnerships between Indigenous and non-Indigenous nations. The content in this session is based on a publication written by Almack et al. (2023) in the Journal of Great Lakes Research.

David F. Reid, NOAA GLERL Retired. **NOAA's Great Lakes Environmental Research Laboratory the first 25 years: Origin, Growth, Struggles, and Scientific Contributions.**

The roots of the National Oceanic and Atmospheric Administration's (NOAA) Great Lakes Environmental Research Laboratory (GLERL) can be traced back to the creation of the U.S. Lake Survey in 1841 within the precursor of the U.S. Army Corps of Engineers. Various organizational changes and new programs within the U.S. government, especially from 1965 to 1970, led to the creation, within NOAA, of GLERL in 1974. Because it was created by merging two existing research programs, GLERL was able to "hit the ground running", but only after moving to facilities in Ann Arbor, MI, and creating a new functional organization. Within two years it had over 60 staff and five major research programs. However, when the lab was only 8 years old, it was targeted for elimination in 1982 as part of the Reagan budget cuts, and it struggled for existence over the next four years. Although it survived, it suffered from mostly stagnant budgets until the zebra mussel was discovered in the Great Lakes, resulting in a large infusion of funds starting in 1992. Just when it looked like threats to its existence were past, GLERL was again targeted by Congress for elimination in the mid-1990s. Despite these struggles, GLERL established and maintained a reputation for scientific excellence and relevancy with a broad program of Great Lakes research, spanning water resources, physical dynamics, biology, chemistry, and climate.

Margaret Rettig, Ryan S. Wagner, George S. Bullerjahn and Christopher S. Ward, Bowling Green State University. **Characterizing the taxonomic diversity and community composition of eukaryotic microbes in Sandusky Bay, Lake Erie.**

Studies characterizing the diversity and ecological roles of prokaryotes, especially cyanobacteria, in the Great Lakes are widespread. In contrast, we know relatively little about the diversity and function of the freshwater microbial eukaryote community. From studies of marine microbial eukaryotes, we know this component of the microbial community plays important roles in

biogeochemical cycling. To understand the ecological contributions of microbial eukaryotes in Sandusky Bay, we examine the spatiotemporal patterns of taxonomic diversity and community composition in the eukaryotic microbial community in Sandusky Bay using high-throughput sequencing of the 18S rRNA gene for samples collected in Sandusky Bay between 2018 and 2020. In our study, we found high diversity of microbial eukaryotes present in Sandusky Bay, including green algae, diatoms, fungi, ciliates, and other heterotrophic microeukaryotes. There is a degree of consistency across our samples, with several taxa being present in many of our samples. We observed a high relative abundance for several divisions, including Ciliophora, Fungi, and Metazoa. Our results provide insight into the structure of the existing microbial eukaryotic community, informing future research regarding ecological function of these microbes and the role of microbial eukaryotes in biogeochemical cycling in Sandusky Bay and other freshwater aquatic ecosystems.

Jessie Reynolds, DataStream. **Data to action: How DataStream's open data platform is used to protect freshwater.**

DataStream is a powerful online platform for sharing water quality data. Across the Great Lakes and St. Lawrence River Basin, community groups, Indigenous nations, NGOs, governments, and academics are collecting valuable water data and uploading it to our free, open access platform. Contributing to DataStream increases the visibility and impact of datasets and amplifies the data in a larger data ecosystem. Data on DataStream is standardized and machine-readable, making it easy to use and compare to other datasets. Great Lakes DataStream has nearly 9 million data points collected by over 65 organizations, and it continues to grow. But more than just numbers, DataStream users turn data into action, making real change to protect water resources. Water data from DataStream informs policy, watershed assessments, research projects, program design, and much more. About half of contributors to DataStream are community-based monitoring groups, meaning that valuable volunteer-collected data has an increased opportunity to be considered in water advocacy and governance. In this presentation, we will tell the stories of how DataStream connects communities, informs decision making, and advances collaborative water stewardship.

Rood Richard, University of Michigan. **Great Lakes Climate Futures: Storylines and Scenarios.**

North America is at the beginning of a time of rapid change, most definitively characterized by the accumulation of heat and generally rising temperatures. The changes in the Laurentian Great Lakes have been especially apparent since the late 1990s. Throughout the early 2000s the persistent increase in temperature got to the threshold where areas that were reliably below freezing for the winter months, often realized temperatures above freezing. This influenced the formation and persistence of lake ice, and all aspects of precipitation. This talk focuses on the development of plausible storylines and scenarios of the climate future of the Laurentian Great Lakes. The goal is to develop narratives which help planning by narrowing possible climate outcomes, and at the same time, providing a meaningful representation of uncertainty. With this approach, a strategy for developing tailored, defensible quantitative knowledge becomes viable. The development of storylines and scenarios proceeds along two paths. The first includes the stories of how the general climatic state of the lake will be changing. The second is to consider scenarios of changes in weather patterns and the behavior of storms that have direct effects on human and ecological systems.

Calvin Rieder, D. Jordan Bouchard and Amy Bilton, University of Toronto. **Pilot-scale Test of a Foam-Based Filtration System for Cleaning Decanted Water in Oil Spill Responses.**

Minimizing the time required to recover an oil spill is critically important for ensuring significant environmental damage is avoided. Skimming is a common response to quickly recover

the spilled oil. One bottleneck in the skimming operation is the limited capacity of storage for the skimmed liquids available at a spill site. Since as much as 80% of a storage tank's contents could be water, Canada is proposing to decant this water and release it to the environment as an alternative response measure. However, the standard decanting process often results in water with oil concentrations above the MARPOL's ANNEX 1 discharge oil content limit of 15 ppm. We constructed a pilot-scale version of a foam-based filter system to clean the decanted water before it is released back into the environment. The system was tested at SL Ross's laboratory with diesel and Endicott crude oil in saltwater. The mixture was fed into the system between 6.0-8.3 lpm with influent concentrations ranging from 38-1711 mg/L. The results demonstrate up to a 99% reduction in oil in the effluent with concentrations below 10 mg/L. These results suggest this technology can filter oil-in-water emulsions to concentrations safe for direct release, accelerating the speed of oil spill response efforts. Future work will evaluate the system using freshwater and to increase the system's processing capacity.

Justin Riley[1,2], Yi Hong[1,2], David Cannon[1,2], Dan Titze[3] and Dima Beletsky[1,2], [1]CIGLR, [2]University of Michigan, [3]NOAA GLERL. **Improving Flood Forecast Guidance for Lake Ontario Through Coupling of the National Water Model.**

Coastal flooding in Great Lakes communities poses a serious threat to ecosystem and economic sustainability. Accurate and efficient flood predictions can provide critical advanced warnings and improve local resilience. The Great Lakes Operational Forecast System (GLOFS) supports coastal infrastructure in the Laurentian Great Lakes by providing wave, current, and water level forecast guidance through the area. However, the current generation of GLOFS lacks a flood plain grid and coupled hydrology model, which are critical for accurate flood forecasting. In this study, we discuss the next generation of Great Lakes modeling systems, which seek to extend model coverage to include these critical coastal modeling features by coupling the hydrologic (National Water Model; NWM) and hydrodynamic (Finite-Volume Community Ocean Model; FVCOM) model domains. We also examine how river channel modifications, such as slope and roughness value, can affect coastal flooding along the coasts of Lake Ontario. Coupling strategies and preliminary results are shared, highlighting enhanced floodplain capabilities and improvements in nearshore water level hindcasts. This study represents a promising step towards enhancing coastal resilience in Great Lakes communities. Ongoing research will focus on the development of the coupled model, with the anticipation of yielding more precise flood predictions and enhancing local preparedness for forthcoming flood events.

Jacques Rinchard[1], Thomas Blowers[2], Jarrod Ludwig[1], Dale Honeyfield[3], Donald Tillitt[4], Brian O'Malley[5] and Brian Lantry[5], [1]SUNY Brockport, [2]USFWS, [3]USGS, [4]USGS Columbia Environmental Research Center, [5]USGS Lake Ontario Biological Station. **The Great Lakes Lake Trout Thiamine Monitoring Program: Trends and Ecological Connections.**

The effort to restore lake trout (*Salvelinus namaycush*) populations in the Great Lakes and surrounding waters has been fraught with challenges. Though stocking has found success in bolstering some of the remaining lake trout populations, a return of consistent natural recruitment of lake trout in the lower Great Lakes remains unachieved. A major impediment has been thiamine deficiency complex (TDC). Insufficient maternal deposition of thiamine (vitamin B_1) into eggs during development is a major consequence of TDC and leads to mass mortality of fry prior to their first feeding. Monitoring of egg thiamine concentrations is a critical indicator for TDC impacts on lake trout populations. Since 2001, the USGS Great Lakes Science Center in cooperation with partner agencies has monitored egg thiamine concentrations in lake trout eggs throughout the

region. The resulting dataset demonstrates high spatial and temporal variability in lake trout egg thiamine concentrations. This presentation will cover the time series produced by the Great Lakes Lake Trout Thiamine Monitoring Program, potential connections to prey fish population dynamics, and upcoming research directions.

Valerie Risch[1], Ceilidh Mackie[1], Jana Levison[1, 2] and James Roy[3], [1]University of Guelph, [2]Morwick G360 Groundwater Research Institute, [3]Environment and Climate Change Canada. **Evaluating Trends in Groundwater and Surface Water Chloride Concentrations within the Credit River Watershed.**

The Credit River Watershed is a rapidly urbanizing area within Southern Ontario (Lake Ontario Basin) where an escalation of anthropogenic impacts on the natural environment is evident. One prominent impact on both aquatic organisms and drinking water quality within the watershed is the increase of chloride concentrations in the groundwater and surface water. This is largely attributed to the excessive application of road salt, predominantly NaCl, as a de-icer on impervious surfaces during winter months in urban areas. The main objective of this research is to gain a better understanding of the long-term trends in chloride concentrations in the groundwater and surface water throughout the watershed, in order to make a well-informed recommendation on management and mitigation possibilities. This is being completed by conducting a field-based investigation at four sites of varying land uses in the watershed. The investigation consists of discrete monthly sampling of the groundwater and surface water, as well as continuous monitoring (i.e., electrical conductivity loggers) and seasonal storm event sampling. Samples are analyzed regularly for major ions, stable isotopes of water, and field parameters. Preliminary results have shown elevated chloride concentrations in the surface water and shallow groundwater locations at the most urban field site. The highest observed concentrations range from 800-2250 mg/L during the winter months. Ultimately, the results of this research intend to highlight the importance of monitoring chloride concentrations in urbanized areas.

Dale Robertson[1], Matthew Diebel[1] and Cal Buelo[2], [1]U.S. Geological Survey, Upper Midwest Water Science Center, [2]U.S. Environmental Protection Agency, Great Lakes Program Office. **Combining monitoring and modeling information to quantify watershed loading at various spatial and temporal scales.**

Nutrient loading and the sources of these loads are needed at various temporal and spatial scales to evaluate effects of wide-scale management efforts and support downstream modeling. However, most large-scale watershed evaluations are made based on monitoring of relatively few sites and modeling conducted for specific time periods. Here, we describe the model-ratio approach that combines monitoring and modeling information to quantify entire watershed loading and the sources of the loads at various spatial and temporal scales. With the model-ratio approach, watershed models provide ratios of nonpoint-source loads between monitored sites and nearby unmonitored areas and estimates of point-source delivery factors, which are used to extrapolate loads from ongoing monitoring programs to the entire watershed at the temporal scale of the monitored loads. The watershed models also provide information on the sources of the nutrient loads. This approach provides more accurate watershed loads than other extrapolation approaches because it incorporates spatial variability in point and nonpoint nutrient sources, watershed characteristics, and hydrology not typically used when estimating nutrient loads from unmonitored areas. The model-ratio approach is being used to estimate daily loading from the U.S. portion of the Great Lakes watershed using monitoring data from Great Lakes Restoration Initiative Tributary Monitoring Network and the Spatially Referenced Regression On Watershed attributes

(SPARROW) model. We are now extending this approach to estimate loads from the entire U.S. and Canadian Great Lakes Basin.

Rylie L. Robinson[1], Silviya V. Ivanova[2], Mathew G. Wells[3], Sarah M. Larocque[4], Jonathan D. Midwood[4], Dimitry Gorsky[5], Scott P. Minihkeim[6] and Timothy B. Johnson[1], [1]Aquatic Research and Monitoring Section, Glenora Fisheries Station, Ontario Ministry of Natural Resources and Forestry, [2]School of the Environment, University of Windsor, [3]Department of Physical and Environmental Sciences, University of Toronto, [4]Fisheries and Oceans Canada, Great Lakes Laboratory for Fisheries and Aquatic Sciences, [5]U.S. Fish and Wildlife Service, Lower Great Lakes Fish and Wildlife Conservation Office, [6]U.S. Geological Survey, Great Lakes Science Center, Tunison Lake Ontario Biological Station. **3D spatiotemporal response of fishes to benthic bathy-thermal gradients in Lake Ontario.**

Temperature is an ecological master factor influencing behavior, survival, and overall distribution of fish and other ectotherms. Remote and continuous in situ measurements of lake thermal structure are common, with most focusing on near surface observations and comparatively fewer studies reporting near seabed temperatures. Fixed moorings of acoustic receivers are rapidly expanding throughout the Great Lakes for the purpose of species-tracking; however, many acoustic receivers concurrently record water temperature. In 2021, coordinated efforts culminated in the complete spatial gridding (~2 to 15km spacing) of Lake Ontario, with acoustic receivers positioned ~2m above lake bottom. Here, we present an analysis of two-years of continuous, near-bottom water temperature and associated fish detection data derived from 418 acoustic receivers distributed throughout Lake Ontario. Our objective was to determine if demersal and benthic fish distribution could be predicted from a heterogenous and dynamic benthic thermal environment. Three-dimensional (3D; lateral and vertical) centers of activity (COAs) were calculated to generate estimates of fish distribution relative to the benthic bathy-thermal gradients. Daily lake-wide benthic temperature layers were geospatially constructed using inverse distance weighting (IDW) interpolation. By overlaying COAs onto interpolated temperature layers, spatial association between fish behaviour and thermal dynamics was established. Behavioural dynamics will be analyzed at different temporal scales - daily to seasonal. Results will be interpreted relative to traditional expectations of species thermal preferences, assessing validity of using near bottom temperatures to infer behaviour.

Jessica Robson, University of Windsor. **Submerged aquatic vegetation macroinvertebrate diversity of Detroit River and tributaries.**

The Detroit River, a Great Lakes Area of Concern, recently upgraded the beneficial use impairment, degradation of benthos, to non-impaired in the Canadian jurisdiction. This assessment focused on sediment contaminant causes of impairment generated at a system-wide assessment. However, macroinvertebrate composition may still be affected at local scales. Prior assessments indicate wetlands within tributaries have long-term water quality impairment, sampling protocols exclude neighbouring, non-wadable, submerged aquatic vegetation beds. This study describes benthic macroinvertebrate diversity of five submerged aquatic vegetation (SAV) beds in-channel and two tributary inlets. Using multivariate approaches, we assess whether community compositions vary across in-channel wetlands and whether two SAV communities, Turkey Creek and River Canard, vary relative to a tributary position. In-channel communities had shown variation by wetland (PERMANOVA, $p<0.05$), where wetlands adjacent to tributaries had lower richness and EPT (3.7%). Hilsenhoff biotic index indicates water quality and organic contaminant conditions are moderately poor to poor (6.09-7.44), water quality was found to be moderately degraded across the

river. The tributary communities of Turkey Creek had demonstrated variation to respective in-channel communities (PERMANOVA, $p<0.05$). Community metrics indicate impairment in the upstream portion of Turkey Creek (1.2% EPT), whereas the tributary communities supported more diversity and sensitive taxa (11.2% EPT).

Madison Rodman[1], Kara Salazar[2,3], Tiffany Sprague[4], Sara Stahlman[5] and Sara Winnike McMillan[6], [1]University of Minnesota Sea Grant Program, [2]Illinois - Indiana Sea Grant , [3]Purdue Extension, [4]University of Minnesota Duluth, [5]Pennsylvania Sea Grant, [6]Iowa State University. **One Block at a Time: Equitable Adaptation through Green Infrastructure.**

The One Block at a Time project focuses on enhancing resilience to climate hazards in four marginalized Great Lakes neighborhoods in Duluth, Minnesota; Erie, Pennsylvania; and Hammond and Michigan City, Indiana. This presentation will outline our approach to identifying neighborhood vulnerabilities, fostering communication between municipal and community leaders through listening and visioning sessions, and implementing small-scale, multi-beneficial green infrastructure solutions. Our community-centric engagement processes were designed to broaden access to climate information, involve diverse groups in planning, and enhance environmental literacy on climate hazards and mitigation strategies and aimed to move from a typical outreach model to a shared leadership model in our community resilience work. In Duluth, partners surveyed neighborhood urban flooding needs and hosted a block party education event paired with a rain-barrel-for-residents program; in Erie, partners focused on relationship building with local communities, developed 3-D models of vulnerable locations, and identified a green infrastructure demonstration site; and the Northwest Indiana projects enhanced neighborhood resilience through integrating rainwater harvesting practices and rain gardens into community gardens in food scarce neighborhoods. We will share how we brought together a diverse team of community members, non-profit organizations (including workforce development), students, and AmeriCorps VISTAs to accomplish our goals. Additionally, the presentation will also address the replicability of our work and share a recently published web-based toolkit on our approach to community-driven engagement and planning.

Collin Roland[1], Paul Reneau[1], Anna Baker[1], Faith Fitzpatrick[1], Will Lund[1] and Eric White[2], [1]United States Geological Survey, Upper Midwest Water Science Center, [2]United States Geological Survey, Water Resources Mission Area. **Benthic habitat classification using side-scan sonar and open-source semantic segmentation models.**

Shallow waterbodies are hotspots of ecological activity and geochemical cycling that harbor disproportionate levels of aquatic biodiversity, but our knowledge of benthic substrate distributions in these habitats remains limited. Traditional benthic mapping techniques in shallow systems frequently rely on time-consuming and sparse manual measurements. In 2023, the U.S. Geological Survey collected >20 square kilometers of centimeter-scale resolution recreational-grade side-scan sonar data to characterize the distribution of bottom substrates in the Rainy River between Rainy Lake and Lake of the Woods in Northern Minnesota. A pre-existing open-source semantic segmentation model was used to classify the sonar data. The classification results largely agree with manual substrate interpretations, but the model was not able to consistently identify sparse wood deposits and long wavelength bedforms, suggesting that model performance may be improved using a location-specific model. Rippled and smooth fine (sand, silt, clay) substrates dominate the study area along with interspersed large wood accumulations. The results from this study demonstrate that recreational-grade sonar equipment can be used to collect high resolution data sets over large areas at relatively low cost. Equally important is that open-source machine learning models for image

classification present a scalable and reproducible approach to quantitatively analyze the large data volumes. In concert, these techniques, along with manual measurements for validation, offer a promising avenue for increasing the density and spatiotemporal coverage of benthic substrate measurements in shallow waterbodies.

Collin Roland[1], Joel Groten[1], Will Lund[1] and Jenny Hanson[2], [1]United States Geological Survey, Upper Midwest Water Science Center, [2]United States Geological Survey, Upper Midwest Environmental Science Center. **Beach nourishment impacts on coastal resiliency at Minnesota Point, Lake Superior.**

Elevated water levels, changing ice dynamics, and anthropogenic modifications of littoral zone sediment transport are exacerbating coastal erosion hazards around the Great Lakes. Minnesota Point, a barrier island near Duluth, Minnesota, has experienced sustained transgression throughout the 20th and 21st centuries and rapid erosion during the recent Lake Superior highstand. In the Fall of 2019, 2020, and 2021, the United States Army Corps of Engineers performed beach nourishments at the northern (Duluth Entry) and/or southern (Superior Entry) ends of the island using dredged material from the Duluth-Superior harbor. The U.S. Geological Survey conducted repeat topobathymetric surveys prior to nourishment and for several years after to monitor the placement and subsequent transport of the nourishment material. The beach nourishments led to widespread recovery of the foreshore and backshore in the Duluth Entry study area, followed by transport from the foreshore and backshore into the nearshore, initiating the reconstruction of nearshore bars. Satellite-derived shoreline timeseries indicate sustained coastal progradation at the Duluth Entry during the study period, while the Superior Entry experienced temporary nourishment-associated progradation followed by renewed transgression. These contrasting responses to beach nourishment highlight the influence of littoral context on the life expectancy of beach nourishments as a method to mitigate coastal erosion. Repeat surveys of beach nourishments allow resource managers to monitor the status of resiliency projects and estimate their ultimate lifespan, improving cost estimates for sustained efforts.

Hunter Roose[1], James Junker[2], Gord Paterson[1], Casey Huckins[1], Christopher Adams[1] and Jill A. Olin[1], [1]Department of Biological Sciences, Great Lakes Research Center, Michigan Technological University, Houghton, MI, [2]Department of Biological Sciences, University of North Texas, Denton, TX. **Dietary niche variation of native brook trout in sympatry with non-native rainbow trout.**

Throughout the Great Lakes watershed, non-native rainbow trout (*Oncorhynchus mykiss*) have been and continue to be stocked into water bodies inhabited by native brook trout (*Salvelinus fontinalis*). Both non-native and native salmonids provide angling opportunities, however their sympatry can present consequences for the native brook trout. In sympatric populations, non-native salmonids have been observed to limit brook trout distribution to suboptimal habitat within a stream and reduce population abundance. These reductions have been attributed to decreasing recruitment related to competition for habitat and food due to highly overlapping life history traits. For example, brook trout, an opportunistic generalist, have demonstrated transitioning to a predominantly terrestrial diet (i.e., drifting invertebrates from riparian vegetation) in the presence of non-native salmonids, potentially reducing competition for similar resources. This study aims to quantify how non-native rainbow trout may alter the resource use of brook trout to help infer how co-occurrence may affect the native populations. To understand this question, we will use community composition and dietary ecological tracer techniques to determine the extent of resource overlap by, i) quantifying the energetic pathways (e.g., drift vs benthic sources) used by both consumers to determine the potential for competition for resources, and ii) determine how

community composition varies temporally. Understanding the patterns of resource use between these species is essential to determining the mechanisms that regulate the coexistence of native and non-native species.

Ed Roseman, U.S. Geological Survey. **St. Clair-Detroit Rivers System Initiative: A Successful Great Lakes Collective Impact Collaboration.**

The St. Clair-Detroit River System Initiative (SCDRSI) is a bi-national environmental initiative that brings together over 30 organizations including U.S. and Canadian natural resource agencies, indigenous peoples, local governments, industry and university partners, non-profits, and interested citizens. The SCDRSI common vision includes the restoration of southern Lake Huron, the St. Clair River, Lake St. Clair, the Detroit River, and western Lake Erie to a thriving ecosystem, using science-based management and broad social support so that improved ecosystem services are provided to the region and Great Lakes basin. The SCDRSI uses a "Collective Impact" approach and a Partnership Agreement to coordinate research and management efforts to achieve measurable progress toward the fulfillment of the Priority Objectives. The strength of the SCDRSI lies in the collective contributions of its partners to the Initiative by providing leadership and guidance, administrative support, planning and implementation of projects, and coordinating and conducting binational research. In 2013, the SCDRSI established priority objectives to guide our work for 10 years (2013-2023) with many efforts focused on remediating and delisting Beneficial Use Impairments within Areas of Concern by restoring habitat for native fishes and improving overall aquatic ecosystem health. This presentation provides an overview of the priority objectives and progress towards achieving our 10-year goals. The presentation will also chart possible courses for what may lie ahead for the SCDRS Initiative Partnership over the next 10 years.

Mark Rowe[1], Peter Alsip[2], Eric Anderson[3], Henry Vanderploeg[4], Jia Wang[1] and David Schwab[4], [1]NOAA GLERL, [2]Cooperative Institute for Great Lakes Research, [3]Colorado School of Mines, [4]NOAA GLERL Retired. **Contributions of NOAA GLERL and Collaborators to Biophysical Modeling in the Great Lakes.**

The NOAA Great Lakes Environmental Research Laboratory has been a leader in the development of numerical models of currents and thermal structure in the Great Lakes, and also in ecological monitoring and experimental studies. Over decades of research, physical lake models have been combined with results of field and laboratory ecological studies to gain insights on the influence of physical processes on water quality and ecology. Several themes have emerged, including 1) the effect of nearshore processes, such as river plumes and suspended sediment, on water quality and ecology, 2) dispersal of early life stages, 3) effects of nutrients, climate, and invasive species on phytoplankton and primary production, 4) harmful algal blooms and hypoxia, and 5) realtime ecological forecasts. As computing power has increased, and lake physical models have included increasing spatial detail, new biophysical modeling applications have become possible. This presentation will provide highlights of topics in biophysical modeling that have advanced over the years, building on GLERL's ecological studies and development of numerical hydrodynamic models in the Great Lakes.

Steve Ruberg[1], Eric J. Anderson[2], Kyle Beadle[1], Steve Constant[1], Ben Downing[3], Katy Frank[4], Andrew Gronewold[5], Lauren Marshall[1], Laura Mendoza[3], Russ Miller[4], Ron Muzzi[4], Heidi Purcell[4], Kristen Rosier[3], Craig Stow[1] and Andrea Vander Woude[1], [1]NOAA Great Lakes Environmental Research Laboratory, [2]Colorado School of Mines, [3]FedWriters at NOAA GLERL, [4]University of Michigan Cooperative Institute for Great Lakes Research, [5]University of Michigan School for

Environmental and Sustainability. **Observing the Great Lakes: The transition to advanced monitoring methods.**

Consistent time-series observations of Great Lakes physical, chemical, and biological parameters provide critical insight into ecosystem change over time. When combined with projects requiring periodic ship sampling, time-series observations fill in the observational gaps between sampling opportunities (daily, weekly, monthly, seasonally) and sampling delayed due to extreme weather events. GLERL's Real-time Coastal Observation Network (ReCON) enables ecosystem episodic event response, supports the needs of NOAA marine forecast validation, provides situational awareness for municipal drinking water managers, and supplies current conditions for commercial and recreational users of the Great Lakes. High resolution real-time measurements obtained year-round from ice-hardened offshore structures can also serve as testbeds for the development of new instrumentation and as reference sites for satellite remote sensing. This presentation will address advanced observational methods deployed by GLERL with a primary focus on data collection from monitoring platforms such as real-time buoys, offshore structures and autonomous vehicles deployed year-round, during winter and operating under ice.

Steve Ruberg[1] and Bopaiah Biddanda[2], [1]NOAA Great Lakes Environmental Research Laboratory, [2]Grand Valley State University. **Lake Huron Karst Groundwater Observations.**

Great Lakes nearshore karst features are being investigated to understand groundwater chemistry with high levels of sulfur and chloride supporting unique anaerobic groundwater ecosystems. The efforts of this project focused on the deployment of sensors to determine groundwater flow rates along with age and chemical makeup. A remotely operated vehicle with a CTD attached and divers were used to collect water samples and deploy sensors in these operationally challenging environments in order to quantify and characterize physical and biochemical properties. Sediment and mat samples collected from sinkhole benthic regions were analyzed using DNA and microscopic methods. Observations obtained during the project have furthered our understanding of groundwater age and provided limited insight into chemical loading from karst systems into Lake Huron.

Laura Rubin, Healing Our Waters--Great Lakes Coalition. **Centering Communities in Great Lakes Restoration.**

The Healing Our Waters--Great Lake Coalition is a coalition of local, state, and regional advocates working together to advance programs and policy solutions at the federal level that address the biggest threats facing the Great Lakes ecosystem and communities. A goal of the Coalition is an updated federal plan for Great Lakes restoration that includes addressing environmental injustice, climate and community resilience, and setting new priorities in light of the evolving ecology of the Lakes. The Coalition worked with social scientists to develop recommendations for the Great Lakes Restoration Initiative Action Plan 4 that provide a more wholistic view of restoration and is especially focused on working to ensure that the communities most impacted by pollution and environmental harm are being prioritized in restoration efforts.

Todd Redder, **Dan Rucinski** and Derek Schlea, LimnoTech. **Advancement and Application of the 3-Dimensional Lake Erie Ecosystem Model (LEEM).**

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, including long-term sediment diagenesis processes. This talk will focus on recent advancements in LEEM's development and demonstrate application of nutrient reduction scenarios.

Jessica Rudnick[1], Kenji Tomari[2], Mark Lubell[2], Kristin Dobbin[3] and Kelly Biedenweg[4], [1]U.S. Forest Service, [2]University of California Davis, [3]University of California Berkeley, [4]University of Oregon. **Establishing social well-being indicators for ecosystem management: comparative learning from the California Delta.**

The California Sacramento-San Joaquin Delta is the largest estuary on the U.S. West Coast, serving as a hub for freshwater resource distribution, a biodiverse ecosystem, productive agricultural land, and a crossroads for statewide infrastructure and transportation networks. Despite statutory mandates calling for scientifically-informed management of the complex balance of competing needs across the estuary, the social dimensions of the Delta have been vastly understudied to date in comparison to decades of ecological health monitoring. Yet in contexts like the Delta where people deeply impact and are impacted by the health of the non-human environment, understanding and tracking change in the social dimensions of the estuary are essential to developing and adapting effective and equitable social-ecological management approaches over time. From 2021-2023, the first Delta Residents Survey was developed and launched to 80,000 residences across the estuary to pilot a social monitoring approach. The survey effort begins to monitor the sense of place, quality of life, environmental change experiences, and civic engagement of residents across the estuary, as key indicators of social well-being. A demographically and geographically representative sample of over 2,300 survey responses was collected and analyzed to develop baseline social well-being measures. This presentation summarizes key findings and relationships from the 2023 survey data and lessons learned in developing and measuring social indicators to inform ecosystem management, which are translatable across geographies.

Ross Ruehmann, Kevin Pankow, Shannon Cressman, Sarah Mansfield, Matthew Kornis and Charles Bronte, U.S. Fish and Wildlife Service. **USFWS Great Lakes Mass Marking Program Leverages Survey123 in the Transition to Digital Data Collection.**

The Great Lakes Fish Tagging and Recovery Lab (GLFTRL), at the Green Bay Fish and Wildlife Conservation Office, has collected field data from sport caught salmon and trout on Lakes Michigan and Huron since 2012 to help evaluate lake trout restoration and provide information to state agencies that manage salmon fisheries. For the past 12 years, field data has been recorded on paper and later entered into Microsoft Excel, requiring significant time for quality assurance and control measures to produce reliable and relatively error-free data for analysis. To transition to digital data collection, the GLFTRL collaborated with a Geospatial Biologist at the Midwest Fisheries Center, located in La Crosse, Wisconsin, to develop a Survey123 data entry form to pilot during the 2023 field season. The form leverages the latest functionality to employ built-in quality control measures and time-saving auto-calculations, all while populating the database in real-time with spatial data. Careful consideration was taken in designing the form to create a user-friendly product that can collect quality data in an extremely high-tempo sampling environment. This ongoing transition to digital data collection has seen early success due to the sound data collection principles already in place by the GLFTRL, while harnessing the latest functionality offered in

Survey123. This presentation will discuss the rationale as well as the benefits and challenges in undergoing this transition for a largescale fisheries survey.

Aaron Rusak, Georgian Bay Land Trust. **Building Coastal Resilience in Georgian Bay.**

The Georgian Bay Land Trust is an environmental non-profit that operates along the eastern coast of Georgian Bay to protect coastal and upland ecosystems. During the course of our work, invasive and provincially-significant species are recorded and ecosystem classification is completed on a variety of habitats. This data feeds into mapping projects to increase the knowledge and capacity to protect Georgian Bay by mapping sensitive ecosystem types and species. These mapping and survey efforts are being used to better understand the composition of Georgian Bay's coastal habitat and will be used to increase resilience across the coast for associated species and ecosystem types. This session will focus on the current work being done to protect and understand the coastal ecosystems of Georgian Bay, focusing on mapping of coastal species and ecosystems, as well as plans for future actions that will increase the resilience of these systems. In addition, some focus will be given to current gaps in our knowledge and steps that the Georgian Bay Land Trust is taking to identify and fill these gaps.

Edward Rutherford[1], Mark Rowe[1], Doran Mason[1], Lacey Mason[1], Andrea Vander Woude[1], Catherine Riseng[2], Lizhu Wang[3], Kevin Wehrly[4], Arthur Cooper[5], Dana Infante[5] and Jeff Tyson[6], [1]NOAA Great Lakes Environmental Research Laboratory, [2]University of Michigan, [3]International Joint Commission, [4]Michigan Dept. of Natural Resources, Fisheries Division, [5]Michigan State University, [6]Great Lakes Fishery Commission. **A Brief Fish-Eye View of GLERLs Physical Science Contributions to Great Lakes Ecological Models.**

Early surveys of the Great Lakes were initiated by scientists at University of Michigan Great Lakes Research Division and other institutions that documented the lakes' physical, geological, and chemical characteristics. NOAA GLERL and Canadian scientists expanded these survey efforts, developing lake physical and environmental models and creating maps that were foundational for understanding Great Lakes ecosystem structure and function. Emerging technologies have enhanced these models and maps with observations at unprecedented spatial and temporal scales including water temperature, depth, water chemistry, bottom type, geomorphology, and currents. *In situ* observations and model products, along with remotely-sensed temperature, chlorophyll *a*, and ice cover, were critical for defining and classifying the structure and function of Great Lakes habitats and food webs. Further, these data and knowledge of physical and environmental conditions and dynamics were incorporated into GLAHF, a spatially-explicit habitat framework that supports ecological model development at multiple spatial scales (whole lakes to nearshore reefs), biological hierarchies (food webs to communities, individuals and life stages), and topics (habitat suitability/restoration to energy flow, predator-prey dynamics and survival). We briefly review GLERL's historic contributions to monitoring and modeling of the Great Lakes ecosystems, and provide examples of their importance for ecological and fisheries models. We suggest continued cross-agency, coordinated sampling and analysis of physical and ecological data be included in GLAHF to inform models of food web and fisheries response to anthropogenic stressors.

Edward Rutherford[1], Henry Vanderploeg[1], Ashley Elgin[1], Paul Glyshaw[1], Eliza Lugten[1], Doran Mason[1], Mark Rowe[1], Steve Ruberg[1], Casey Godwin[2], Subba Rao Chaganti[2], Russ Miller[2], Peter Alsip[2], Andrew Camilleri[2], Madeline Tomczak[2] and Hunter Carrick[3], [1]NOAA Great Lakes Environmental Research Laboratory, [2]University of Michigan, [3]Centeral Michigan University.

NOAA's coordinated sampling of water quality and lower food web dynamics in Lake Huron 2022.

Lake Huron faces multiple stressors including climate, land use change and invasive species, but interactive effects of these stressors on lower food web structure and function remain undefined. In 2022, NOAA GLERL and university partners conducted field surveys, ran models and deployed new technologies to address CSMI priorities of nutrient and bacterial pollution, habitat and native species, invasive species, and other stressors. We surveyed dreissenid mussels in Saginaw Bay and Thunder Bay (SB/TB), and assessed mussel condition and reproductive status lake-wide during the CSMI benthic survey. At sites along nearshore-offshore transects in SB/TB, we deployed sensors to record variation in UV, CDOM, temperature and light together with organism movement and predator-prey interactions within the lower food web. We sampled water to measure nutrients, optical properties, size-fractionated primary production and microbe biomass, and used nets to estimate zooplankton and larval fish abundance. We made continuous measures of abiotic factors including water temperature, chlorophyll a, zooplankton and fish biomass using a plankton survey system and fisheries acoustics. A biophysical model was used to provide nowcasts and forecasts of larval fish transport and hindcasts of presumed spawning locations, and also simulated nutrient and chlorophyll concentrations and fluxes. Data from satellite remote sensing products and un-crewed systems expanded spatio-temporal coverage of abiotic drivers of primary productivity between nearshore and offshore regions. Results will be presented and compared with earlier CSMI surveys.

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Eric Saas[1], Janice Kerns[1] and Lauren Kinsman-Costello[2], [1]Ohio Department of Natural Resources, [2]Kent State University. **The H2Ohio Wetland Restoration & Wetland Monitoring Programs: Managing Wetland Restoration for Water Quality.**

Ohio Governor Mike DeWine created the H2Ohio Initiative in 2019 as a comprehensive, data-driven approach to reduce harmful algal blooms, enhance water quality, and improve water infrastructure in Ohio. H2Ohio functions as an integrated, collaborative water-quality partnership among state agencies, non-profit conservation organizations, the research community and others. H2Ohio focuses specifically on incentivizing agricultural best management practices, upgrading water infrastructure and, under the auspices of the Ohio Department of Natural Resources (ODNR), restoring and enhancing wetland and related habitat to improve surface water quality. Since 2019, ODNR and their project partners have initiated over 170 grant-funded natural infrastructure projects and partnered on more than 190 private lands wetland and riparian restoration projects, setting in motion approximately 15,500 acres of wetland and associated habitat restoration. The ODNR prioritizes restoring wetland ecosystem function as a relatively low-cost mechanism to reduce surface water nutrient loading and eutrophication over the long term while also generating numerous beneficial add-on effects, such as the creation of habitat for endangered species and providing increased recreational opportunities. The ODNR H2Ohio Program has partnered with the Lake Erie and Aquatic Research Network's H2Ohio Wetland Monitoring Program to measure the impact of H2Ohio restoration projects on nutrient loading. This monitoring program increasingly enables ODNR, its partners and others to make the better project selection and restoration design choices to optimize water quality benefit.

Nayereh Saborimanesh, Natural Resources Canada. **Effect of Sunken Bitumen on Freshwater Sediment Microbial Communities and Nitrification.**

Following an oil spill in an aquatic environment, the heavier compounds of oils are deposited to the bottom sediment in the form of oil-sediment mixtures or oil-mineral aggregation. However, the risk of exposure to sunken heavy oils (i.e., bitumen) or high molecular weight constituents of oils on the benthic microbial community structure and activities has not been well understood. The objective of this work was to improve the understanding of the effect of sunken bitumen or bitumen-derived asphaltene on sedimentary microbial communities in freshwater. Laboratory-scale tests were performed at 20°C and under aerobic conditions. Sedimentary microbial communities in the North Saskatchewan River (AB, Canada) and nitrifying-enriched sediment were exposed (< 90 days) to sunken bitumen or asphaltenes and the microbial community structure and nitrification process (measured as total nitrogen) were monitored over the experimental period. Analysis of the 16S rRNA gene sequencing showed that the exposure of sediment to sunken bitumen or asphaltenes altered the microbial community structure in the sediment and affected the nitrification process (measured as total nitrogen). This work provides information on the ecological effects of less studied fractions of crude oils on freshwater microorganisms.

Lauren Saggese, Wendy Owens and Christy Tyler, Rochester Institute of Technology. **Effects of Soil Amendments on Community Structure and Function in Created Wetlands.**

Wetlands provide many ecologically valuable services like carbon sequestration, flood mitigation, water purification, and habitat provision, but continued degradation has led to continual wetland loss. To combat this loss, policy requires creation and restoration of wetlands to replace lost function. However, created wetlands often do not provide functions and services equivalent to natural wetlands. The addition of carbon-rich plant compost has been shown to alter soil characteristics and biogeochemistry in wetlands. However, the impacts on wetland community structure are unknown. We evaluated changes in community structure of invertebrates and plants, and assessed photosynthesis and community metabolism in three wetlands where a long-term leaf-litter compost experiment was established. Compost addition led to significant increase in soil metabolism, organic matter and nutrient content. Microalgal chlorophyll *a* concentration varied seasonally across all sites, with compost decreasing chlorophyll *a* in spring and fall. There were also impacts on soil macroinvertebrate and plant communities that varied across sites. These results suggest cascading and site-specific effects of carbon addition on wetland community structure and function, and indicate that in some cases leaf-litter compost may be a valuable management tool to improve restoration outcomes.

Ratnajit Saha, Alex Neumann, Aisha Javed and George Arhonditsis, University of Toronto. **Landuse changes and agricultural impacts on GHG emissions in a changing climate in Ontario, Canada.**

Agricultural practice is a significant contributor to greenhouse gas (GHG) emissions, and knowledge of spatial and temporal agriculture trends in Ontario is essential to extend the practices to ensure food security. Canada has committed to the Paris Agreement to reduce GHG emissions by 30% below 2005 levels by 2030 and net zero by 2050. The study aims to investigate the change in agricultural land use and its impact on GHG emissions in a changing climate in Ontario, Canada. The WinBUGS was used to detect significant changes in cropland and livestock across Ontario. The HOLOS (version 4.0), an empirical farm-scale model, was used to calculate GHG emissions and identify alternative management strategies to reduce the emissions in a virtual farm. Over the last seven decades, major cropland areas have been extended mostly in southern and western Ontario.

Highly agricultural counties emitted 110,472 to 1,060,425 $MgCO_2e$ (42 to 383 $MgCO_2e/Km^2$) in 2016. County-wise total and emission/km^2 increased from 5.3% to 34.6% $MgCO_2e$ and 5.0% to 25.7% $MgCO_2e/Km^2$, respectively, from 2001 to 2016. Combining low-energy protein, 4% fat, confinement in a barn, and anaerobic digestion would help to emit a low amount of enteric CH_4 (the most prominent contributing GHG) in the farm. The study findings will contribute to provincial and national agricultural strategies to achieve "net zero carbon emission" and help to develop nature-based solutions for the carbon-smart ecosystem.

Halima Salah[1], Ying Xiong[2], Debatosh Partha[1], Wenfu Tang[3], Simone Tilmes[3], Noribeth Mariscal[1], Like Wang[1] and Yaoxian Huang[1], [1]Wayne State University, [2]University of Michigan, [3]National Center for Atmospheric Research. **Comparing Global Anthropogenic Emission Inventories and Their Impacts on Air Quality and Human Health.**

Spatial and temporal variability of gridded short-lived climate forcer (SLFCs) emissions exist within 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 three anthropogenic emission inventories, namely the Community Emissions Data System (CEDS), the Copernicus Atmosphere Monitoring Service (CAMS), and Evaluating the Climate and Air Quality Impacts of Short-Lived Pollutants version 6b (ECLIPSEv6b), respectively. We then used 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 assess the associated regional and global air quality impacts. Lastly, we conducted an inter-comparison of global human health impacts from the above three anthropogenic emission inventories attributable to long-term $PM_{2.5}$ (particulate matter with aerodynamic diameters equal or less than 2.5 microns) and ozone exposure. This is especially crucial in the Great Lakes region, where annual asthma cases are prevalent. The research findings serve as a useful reference for policymakers seeking effective and sustainable strategies to mitigate air pollution and the associated health impacts.

Thomas Saleh[1], Chris Hay[1], Zephaniah Migeni Ajode[1, 2], Sarah Warrack[1], Chris Herc[3], Dilber Yunus[1] and Pauline Gerrard[1], [1]International Institute for Sustainable Development, [2]African Center for Aquatic Research and Education (ACARE), [3]Grand Council Treaty #3. **Democratizing Science? Public Engagement in Ecological Research, Policy, and Practice.**

Technological innovations continue to render science more affordable and accessible to citizen scientists and the public. At the same time, public perceptions of science and its relationship to public policy and practice are shifting, leading to calls for a "democratization of science". In recent years, IISD has been engaging local communities in many aspects of the scientific process - from collecting data to proposing policies and practices. Through our research at the Experimental Lakes Area and far beyond, we have been asking: What is the role of public engagement in developing policy-relevant ecological research? This presentation will provide an overview of our efforts to work with local communities on data collection, analysis, and sharing, as well as in translating scientific research to policy and practice. These relationships have brought opportunities for knowledge sharing and broadening the reach and impact of our research, while also presenting challenges around reliability of the findings, data sovereignty, and sustaining engagement.

Phoenix Sandrock, Joshua Culpepper, Aman Basu and Sapna Sharma, York University. **Declining ice duration alters key ecosystem parameters in lakes worldwide.**

Lake ice duration is declining worldwide, which will affect the structure and function of ice-covered lake ecosystems. However, lake ecosystem responses to ice loss remain poorly studied. A global analysis of changing under-ice ecology is necessary to understand how lakes will respond to declining ice duration. We examined 21 lakes in North America, Europe, and Antarctica. We find that shorter ice durations are weakly correlated with warmer under-ice water temperatures (R^2 = 0.35), reduced dissolved nitrogen (R^2 = 0.37) and phosphorus (R^2 = 0.35) concentrations, higher under-ice chlorophyll *a* concentrations (R^2 = 0.34), and higher zooplankton abundances (R^2 = 0.07) in lakes worldwide. These parameters represent key ecosystem processes in lakes, and changes in these processes can alter lake ecosystem function over time, particularly under more severe climate warming. This global analysis improves our understanding of how lake ecosystem parameters change in response to ice loss and provides information that may help preserve lakes and the ecosystem services they provide under future climate warming.

Mithra Sankrithi, RIC Enterprises. **Harnessing the Great Lakes for the World's Largest Pumped Storage System.**

For America to achieve the 100% clean electric grid strategic goal by 2035, many hundreds of gigawatts (GW) of daily or longer-term energy storage will be needed to compensate for the intermittencies inherent to solar, wind and tidal power. This presentation will summarize an opportunity to develop a pumped storage system between Lake Ontario and Lake Erie for around 400 GW generating capacity and annual storage of around 1,000,000 GWh with daily cycling- over a hundred times the capacity of the world's largest current pumped hydro system. This opportunity scales up the well-proven technologies of pumped hydro and can bring a quarter-trillion-dollar infrastructure project to the Great Lakes region with extraordinary economic and job creation benefits. The presentation will summarize a preliminary system design and identify avenues to ensure win-win solutions that: benefits all stakeholders; boost the economy and tourism in NY and Ontario; require no new land submergence; reduce flooding risk for waterfront properties; and also meet stringent safety, erosion, ecology and environmental standards and regulations. A roadmap to implementation of such a unique system as a pivotal element to enable the 2035 100% clean electricity target will require engagement and coordinated efforts of stakeholders & governments in the USA, Canada, New York and Ontario. The benefits can be enormous in establishing clear American leadership in enabling a green future for humanity!

Maiza Saqib and Trevor Pitcher, University of Windsor. **Effects of structural enrichment on juvenile hatchery-reared Atlantic salmon (Salmo salar).**

This study investigates the effects of structural and nutritional enrichment on juvenile hatchery-reared Atlantic salmon (*Salmo salar*). Structural enrichment is a form of environmental enrichment that involves the incorporation of physical complexity into the housing of a captive animal. Additionally, nutritional enrichment is the addition of nutrients to the feed. The experimental design of this study encompasses four treatment conditions: a control group, structural enrichment, nutritional enrichment, and a combination of structural and nutritional enrichment. The investigation focuses on brain and body morphology to assess the effects of enrichment strategies. Brain morphology analysis involves studying five brain regions: the olfactory bulb, telencephalon, optic tectum, cerebellum, and hypothalamus. Previous studies suggest that enrichment may lead to size, shape, and connectivity alterations within these neural structures. Additionally, body morphology can be altered based on environmental conditions and is an important measure of

fitness in salmonids. Body morphology will be assessed using body landmarking techniques to determine body shape induced by the various enrichment conditions. By employing this multifaceted approach, the study aims to provide insights into whether structural and nutritional enrichment have effects on brain and body morphologies in Atlantic salmon fry. Furthermore, the findings aim to improve captive breeding in ways that increase the fitness of captive-bred individuals and, ultimately, contribute to ongoing efforts to optimize the rearing conditions of Atlantic salmon in captivity, ensuring their fitness and success upon reintroduction.

Nicholas Sard[1], Sam LaSalle[2], Georgie Hoffman[2], Joe Sweeney[1], Collin Atwood[1], Lucas LaTarte[2], Matt Nguyen[2], Ryan Walquist[2] and Brian Weidel[2], [1]SUNY Oswego, [2]USGS-GLSC. **Geonotyping larval coregonines provides insights into Lake Ontario adult breeding and offspring dispersal patterns.**

The ecological drivers and evolutionary consequences of coregonine reproduction have been challenging to study in the Laurentian Great Lakes, in part, because breeding adults and age-0 offspring are difficult to sample. In 2023, 1,120 coregonine larvae were sampled in Chaumont Bay, Lake Ontario, using newly developed gear to evaluate emergence rates among various habitats, including newly constructed reefs. Coregonine larvae were also sampled throughout the embayment with towed ichthyoplankton nets. Genomic DNAs were extracted from larvae and used to amplify loci that were recently developed for a coregonine-specific genotyping-by-thousands sequencing panel. Larval genotypes will be used to reconstruct pedigrees via the full-likelihood implementation of COLONY without parental genotypes. Based on larvae sampled within emergence traps, familial relationships will be used to test if the number of parents that produced offspring differed among specific habitats. Larvae sampled in tows will be used to investigate dispersal among siblings within the bay and estimate the effective number of breeders (Nb) within and among habitats. Results will provide information on coregonine reproductive ecology, how siblings dispersed within the embayment after fertilization, and evaluate how estimates of Nb vary with the sample size and spatial scale.

Michael Sayers[1], Bob Shuchman[1], Karl Bosse[1], Gary Fahnenstiel[1], Steve Ruberg[2], Andrea Vander Woude[2] and George Leshkevich[2], [1]Michigan Tech Research Institute, [2]NOAA GLERL. **Satellite Monitoring of Water Quality in the Great Lakes: The Past, Present, and Future.**

Over the past 20 years satellite remote sensing technologies have emerged as an important tool for monitoring water quality in the Great Lakes. Algorithms specific to the Great Lakes have been developed to estimate trends in phytoplankton biomass and production, water clarity, submerged aquatic vegetation, and harmful algal blooms. These remote sensing products augment field observations that are costly and lack continuity to capture the range of spatio-temporal variability of phenomena. A productive collaboration between academia and NOAA GLERL, USGS, and EPA, has provided a set of in situ optical properties and water quality parameters to advance algorithm development and derived product validation. Because of these collaborations, remote sensing satellite products are being used in the decision-making process at the federal level. There have been increased efforts to collect *in situ* bio-optical calibration and validation datasets to further the development of increasingly sophisticated approaches to provide more products with better accuracy. The development of new remote sensing technology including airborne and spaceborne hyperspectral imaging such as the NASA PACE mission and Light detection and ranging (LiDAR) opens the door for more monitoring capabilities in the future. This talk synthesizes the historical development of Great Lakes remote sensing approaches, provides examples of the

current state of the art algorithms and applications, and projects future advancements in sensing technologies that will lead to the next-generation of retrievable parameters and improved accuracy.

Olivia Schloegel[1], Lauren Kinsman-Costello[1], Raissa Mendonça[1], Janice Kerns[2], Eric Saas[2] and Rachel DeNoewer[2], [1]Kent State University, [2]Ohio Department of Natural Resources. **Cultivating Science-Policy-Practitioner Partnerships in Wetland Restoration.**

Setting a goal to understand nutrient reduction in restored wetlands provides an opportunity to promote inter-institution dialogue around scientific assessment and management realities. The H2Ohio Wetland Monitoring Program mobilizes university researchers across Ohio to investigate the effectiveness of state agency-funded wetland projects. Sustained working relationships with wetland practitioners capture relevant metrics around wetland design and management decisions. The Program's annual workshop connects >30 academic scientists and technical staff with agency and management partners for a series of structured activities and informal networking. Likewise, researchers exchange knowledge with land managers through a combination of standardized prompts and unstructured field visits, the latter of which catch insights not always detected in written form. Dialogue in each space grounds the Program's purpose in acquiring actionable data, without sacrificing independent scientific research. The Program maintains workflows for inter-institution communication across the life cycle of a wetland project (i.e., design, construction, present use) and integrates management-related metrics into monitoring design (i.e., sampling locations near water level control structures, avoiding sensitive features upon land manager request). The first two years of the Program offer emergent themes to frame next steps in the broader space of "science-informed management"; considering how to balance expectations of urgently requested information with the scientific reality of monitoring ecological change. Ultimately, investment in wetland practitioner partnerships can strengthen understanding of wetland nutrient services in human-altered landscapes and human-managed ecosystems.

Amber Schmidt[1, 2, 3], Hillary Glandon[1, 2, 3], Andrew Phillips[1, 2, 3, 4] and Sergiusz Czesny[1, 2, 3], [1]University of Illinois Urbana-Champaign, [2]Prarie Research Institute, [3]Illinois Natural History Survey, [4]Illinois State Geological Survey. **Ecological and Geological Response to the Introduction of a Nearshore Reef in Southern Lake Michigan.**

The Great Lakes are highly susceptible to costal erosion through weather events, changing water levels, and wave action. These receding coasts are problems for both cities and natural areas across the Great Lakes. Historic solutions to this long-term problem have been temporary and provide little benefit to the natural environment. The Rubble Ridges, constructed in 2021 near Illinois Beach State Park in southwestern Lake Michigan, is an artificial reef system designed to be a dynamic, natural solution that prevents erosion and repairs the natural shoreline while also providing aquatic habitat. The intent of this study is to determine if a newly constructed nearshore artificial reef impacts the local sediment characteristics at the reef, and if these changes in sediment may influence the utilization of the reef by the benthic community. We used benthic cores, collected round goby (*Neogobius melanostomus*) stomachs as well as sediment cores and scrapes of biota attached to the reef structures at the Rubble Ridges and nearby control site (4.8km south) to determine the effects of this newly constructed artificial reef on benthic community species abundance and diversity and sediment structure. This study provides a unique opportunity to quantify geological and ecological changes at newly introduced structure in Lake Michigan.

Kailee Schulz[1], Peter Esselman[1], Shadi Moradi[1, 2], Anthony Geglio[1] and Alden Tilley[1], [1]USGS, [2]Michigan Tech Research Institute. **Round goby (*Neogobius melanostomus*) inter-lake biomass estimates and size frequencies across physical habitat features in the Laurentian Great Lakes.**

The round goby (*Neogobius melanostomus*) was introduced to the Laurentian Great Lakes in 1990 and spread at a faster rate than any previous fish invader. Their successful invasion and rapid establishment was, in part, due to the species habitat flexibility. It is well established that round goby have an affinity for structurally complex habitats in comparison to sand or mud substrates. However, there appears to be a gradient in habitat usage dependent on the size and/or age structure of the round goby population. Camera-based imaging and deep-learning technologies were used to collect and estimate round goby biomass and individual size estimates for tens of thousands of individuals in three Great Lakes. Results provided an inter-lake comparison of Round Goby density and biomass across lakebed substrates and water depths. Utilizing estimated round goby size frequencies, the effect of length and age on habitat usage was assessed across and between the three lakes. While several studies have focused on this topic, especially biomass estimates of round goby in the Great Lakes, there is still a need to assess size and age structure of round goby populations as they relate to habitat features on a lake-wide and multi-lake scale.

David Schwab[1] and **Eric Anderson**[2], [1]NOAA GLERL Retired, [2]Colorado School of Mines. **Great Lakes Coastal Forecasting System - the Long and Winding Road from Research to Operations.**

The Great Lakes Coastal Forecasting System (GLCFS) is an interconnected set of computer models that predict physical conditions (e.g., water level fluctuations, currents, thermal structure, waves, ice dynamics) of the lakes and connecting channels in a real-time nowcast and forecast mode. The GLCFS is designed to provide timely surface water condition information to carriers, mariners, port and beach managers, emergency response teams, and recreational boaters, surfers, and anglers. Users are able to select a category and lake of interest to visualize the current and future surface water conditions as time series, maps, and animations. The GLCFS was originally developed at NOAA's Great Lakes Environmental Research Laboratory (GLERL) and The Ohio State University (OSU) in the late 1980s. Through a sustained collaboration between GLERL, NOAA's National Weather Service, and NOAA's National Ocean Service, GLCFS was eventually incorporated into NOAA's operational run stream and the products are now routinely disseminated by NOAA's Center for Operational Oceanographic Products and Services (CO-OPS), the nation's authoritative source for accurate, reliable, and timely water level and current measurements. This talk will describe GLERL's essential role in shepherding GLCFS down the long and winding road from its early development at GLERL and OSU to the current operational system at NOAA CO-OPS.

Anne Scofield[1], Stephanie Figary[2], Julie Lietz[3], Joseph Connolly[2], Christopher Marshall[2], Lars Rudstam[2] and James Watkins[2], [1]Environmental Protection Agency, [2]Cornell University, [3]General Dynamics Information Technology. **Long-term trends in Great Lakes shallow zooplankton communities.**

Zooplankton abundance and community structure are commonly used as indicators of ecosystem state in aquatic systems, and zooplankton data provide insights into differences in ecosystem function across lakes and over time. The EPA Great Lakes National Program Office (GLNPO) has monitored zooplankton communities in all five Great Lakes during spring and summer for more than two decades using both deep net tows (0-100 m or 2 meters off the bottom,153 μm mesh) and shallow net tows (0-20 m, 63 μm mesh). While all samples are analyzed

for crustacean zooplankton community, the shallow net tows are also analyzed to assess microzooplankton, including nauplii, rotifers, and dreissenid mussel veligers. We present results from shallow tow monitoring data for 2001-2022 from 72 GLNPO routine monitoring sites and evaluate variation in surface layer zooplankton community structure across lakes, years, and seasons. We present trends in shallow zooplankton community structure, discuss how they compare to previously reported patterns for whole water column zooplankton, and highlight the contributions of microzooplankton to total zooplankton biomass across the lakes.

Elizabeth Hinchey[1], **Anne Scofield**[1], Erica Yang[1], Lyubov Burlakova[2], Alexander Karatayev[2], Susan Daniel[2] and Julie Lietz[3], [1]United States Environmental Protection Agency Great Lakes National Program Office, [2]State University of New York Buffalo State, [3]General Dynamics Information Technology. **Long-Term Monitoring of Muddy Macrofauna - EPA GLNPO's Great Lakes Benthic Monitoring Program.**

Recognizing the importance of benthic community monitoring for the assessment of Great Lakes ecosystem health and impacts of disturbance, in 1997 EPA GLNPO added a benthic invertebrate monitoring component to the EPA Great Lakes Biology Monitoring Program. A unique strength of GLNPO's benthic monitoring program is the extent of spatial and temporal coverage, which includes all five lakes and collects data from 58 permanent stations on an annual basis and up to 100 additional stations per lake during each Cooperative Science and Monitoring Initiative intensive field year. Data generated from this program have been integral in tracking profound changes to the native profundal benthic community wrought by the ecological engineering of invasive dreissenid mussels, as well as tracking changes in dreissenid population changes through time. This talk will present an overview of the evolution of the monitoring methods and scope, feature highlights of major assessments/ecosystem insights/products generated by the program, and share an inventory of open data available to stakeholders.

Frank Seglenieks[1], Lauren Fry[2] and Deanna Fielder[3], [1]ECCC National Hydrological Service, [2]NOAA Great Lakes Environmental Research Laboratory, [3]U.S. Army Corps of Engineers Detroit District. **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) work flow. 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. In particular, GLAM is currently in the second phase of their expedited review of the current regulation plan for Lake Ontario (Plan 2014). Part of this review involves the testing of updated regulation plans under a variety of plausible hydroclimate conditions. This work has led to advances in ice forecasting, future climate change and stochastic scenarios, and machine learning applications. We will present recent and ongoing progress made (and gaps identified) by GLAM and its partners to advance hydroclimate data and modeling.

Kyla Semmendinger-Raney[1], Yi Hong[1], Lauren Fry[2] and Scott Steinschneider[3], [1]Cooperative Institute for Great Lakes Research, [2]NOAA Great Lakes Environmental Research Laboratory, [3]Department of Biological and Environmental Engineering, Cornell University. **Leveraging Subseasonal-to-Seasonal Forecast Information and Many-Objective Direct Policy Search to Support Regulation Decision-Making in the Lake Ontario - St. Lawrence River Water System.**

Lake Ontario is one of the largest managed lakes in the world, with outflows regulated at the Moses-Saunders Dam. System stakeholders rely on outflow regulation to meet many needs, including flood protection, Seaway navigability, and wetland conservation. The current control policy, Plan 2014, is the first of this system to use supply forecasts to inform release decisions. In past work, we identified constraints within the release function of Plan 2014 that inhibit the policies from utilizing forecasts of improved skill or of alternative lead-times to improve performance across system objectives. In this work, we pair multi-objective optimization and global approximator functions to identify alternative, flexible control policies that can better utilize forecast information by reducing structural constraints in rule curve design. Policies are informed by supply forecasts at various lead-times (1, 3, 6, 9, and 12 month) and levels of skill (persistence-based and perfect forecasts). We optimize each forecast-informed policy under the historic supply trace to balance flood reduction, hydropower production, commercial navigation, wetland biodiversity, and recreational boating. A subset of policies is re-evaluated under an ensemble of stochastic and climate-change driven water supply series. 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.

Ronald Semyalo[1], Drake Ssempijja[2], Jerome Lugumira[3], Simon Peter Sserwambala[1], Peter Akoll[1], Godfrey Kawooya Kubiriza[1] and Robinson Odong[1], [1]Makerere University, [2]University of Massachusetts Dartmouth, [3]National Environmental Management Authority. **Environmental Impacts and Integrated Water Resources Management in Ugandan Aquaculture: A Study Fish farms in the Lake Victoria Basin.**

Since the early 1990s aquaculture in Uganda has been growing both in production and intensity. A study was conducted in 119 Fish farms in the Lake Victoria Basin in three of the major aquaculture production districts (Mukono, Jinja and Buikwe), to examine whether this growth is matched by the environmental protection practices. Fish farming is a male dominated enterprise, largely due to land ownership privileges, there is a notable link between land tenure and farming intensity. Significant growth in farm numbers was after 2014, with the largest number and size of farms in Mukono District. A significant portion of farms was poorly maintained, with common surrounding land uses being plant cultivation and woodland forest. The primary water sources were spring and lake water, with water quality generally meeting FAO standards, despite some concerns like high ammonia and chlorophyll a level in ponds. Regarding feed, most farms relied on factory-made feeds, supplemented by farm-made options, with predominant feeding methods being response feeding and ration feeding. The study revealed that most farms did not treat aquaculture effluent before releasing it into natural water bodies. The main waste sources were organic matter and dead fish, with waste management primarily involving incineration and burying. These findings underscore the need for better farm maintenance and waste management to promote sustainable aquaculture in these districts.

Jacqueline Serran[1] and Mike Moroney[2], [1]Detroit River Canadian Cleanup, [2]St. Clair Region Conservation Authority. **Restoration of Beneficial Uses in the Detroit and St. Clair River Areas of Concern.**

The Detroit River and St. Clair River were listed as Areas of Concern (AOC) under the Great Lakes Water Quality Agreement in 1987 following decades of industrial and municipal discharges and physical changes to the shorelines and riverbed. The severe degradation of the aquatic environment led to the impairment of many of the fourteen beneficial uses also listed under the Agreement. To restore the health of these rivers, AOC-specific Remedial Action Plans (RAP)

were developed, each detailing restoration goals and recommended actions to meet them. After nearly four decades of completing scientific studies and implementing remedial actions, significant progress has been made yet four beneficial use impairments remain in each AOC. This session will highlight the research, monitoring, and restoration projects that have been completed, are underway, and planned to address the remaining four beneficial use impairments and ultimately, delist the St. Clair River and Detroit River as AOCs.

Julia Shablin, Miranda England, Amanda Suchy and Donald Uzarski, Central Michigan University.
Effects of vegetation on microplastic concentrations in Great Lakes coastal wetlands.

Microplastics are plastic particles (<5mm) that have been found in nearly all environments. Microplastics have the potential to negatively impact human and wildlife health via ingestion and carry and transport toxins on their surface. Wetlands may be particularly vulnerable to microplastic accumulation as vegetation can trap small particles and reduce water velocity promoting settling of microplastic particles. Our objective was to examine how vegetation may affect microplastic concentrations in coastal wetlands in the Great Lakes. Sediment samples were collected from 15 sites as part of the long-term Coastal Wetland Monitoring Program during the summer of 2022. At each site, sediments were collected from up to three dominant vegetation zones including *Typha sp.*, *Schoenoplectus sp.*, and *Phragmites sp.*. Microplastics were extracted from sediments via $CaCl_2$ density separation after wet sieving (0.3-5 mm) and removal of organic matter (30% H_2O_2). Microplastics were collected on a filter and manually counted using a dissecting microscope. We found average microplastic concentrations were not significantly different between patches of *Typha sp.* (189 particles/L soil) and *Schoenoplectus sp.* (138 particles/L soil). However, microplastic concentrations were more variable in patches of *Typha sp.* patches (range = 73 - 264 particles/L soil) than in patches of *Schoenoplectus sp.* (range = 89 - 180 particles/L soil). This suggests that certain patches of vegetation, such as *Typha sp.*, may be more vulnerable to hotspots of microplastic deposition.

Lamees Shah[1], Carlos Alberto Arnillas[1], Symon Mezbahuddin[2], Christopher Wellen[3] and George Arhonditsis[1], [1]University of Toronto, [2]University of Alberta, [3]Toronto Metropolitan University.
Representing common crops in southern Ontario using the ecosys model.

Eutrophication is an ongoing problem in waterbodies all around the world. In Ontario, management practices that increase vegetative presence on agricultural fields such as cover crops have been recommended as a strategy to control non-point source pollution to the receiving water. Mechanistic models are proposed as useful ways to test the practices in a site, given the wide range of factors to consider for implementation, complementary management, and context-specific characteristics. Cover crops as any plant may change the physical, chemical, and biological environment for the next crop, or also for the current crop if seeded before harvest of that crop. These changes can shift nutrient fate and transport if they impact nutrient release and water dynamics, as well as plant growth and litter turnover. Therefore, it is crucial not to forsake the biological component of the cycles. Using available climate, topography, soil, and management data of a range of fields in southern Ontario, we implement a field-scale mechanistic model called ecosys and explore the model capability to represent common crop rotations and thus the ability to test the diversified practices in the area.

Ali Shakoor and Donna Kashian, Wayne State University. **Impacts of *Microcystis* and Microplastics exposure on green frog tadpole length, weight, and body condition.**

Aquatic systems are increasingly impacted by multiple stressors. Harmful algal blooms (HABs) are occurring with increased frequency and duration, concurrently with increasing quantities

of microplastics. Both have known individual environmental impacts, but interactive effects are poorly understood and even less is known about their impacts on amphibians. Many nutrient rich shallow nearshore areas of the Great Lakes frequently experience HABs dominated by *Microcystis spp.,* while also being subject to runoff ladened with microplastics. These nearshore areas, including Great Lake **coastal wetlands,** are important habitats for amphibian species. The objective of this study was to determine the impacts of environmentally relevant levels of *Microcystis ichthyoblabe* and microplastics on green frog tadpoles. Green frog tadpoles were hatched from wild collected eggs and raised in environmental chambers for five weeks, until exogenously feeding. Tadpoles were then exposed to two concentrations ($1x10^4$ cells/ml and $4x10^4$ cells/mL) of *M. ichthyoblabe*, and *Chlamydomonus, a non-toxin producing green algae, and* 10mg/L of microplastics across all treatments. *Tadpole* length, weight, and body condition were measured after 14 days. Preliminary results indicate high concentration of cyanobacteria and microplastics negatively impacted growth of green frog tadpoles. Understanding how early life-history stages of green frogs interact with stressors, such as HABs and microplastics, may lead to a better understanding of how they may affect frog populations, thereby providing valuable information to help understand how trophic interactions are impacted by these stressors.

Emily L Shaw[1], Valoree S Gagnon[1], Evelyn Ravindran[2], Dione Price[2], Noel R Urban[1] and Shan Zhou[3], [1]Michigan Tech, [2]Keweenaw Bay Indian Community Natural Resources Department, [3]Purdue University. **Local remediation can decrease local concentrations of ASEPs - a policy analysis of PCB concentrations in the Great Lakes basin.**

In response to generations of inequitable research to/for Indigenous communities, many have and are developing research practices that center Indigenous priorities. The Seasons of Research framework was developed by the Keweenaw Bay Indian Community and University collaborators to govern research partnerships. The guidance aims for balance between and among four seasons of research: relationship building, planning and prioritization, knowledge exchange, and synthesis and application. As a fishing community, rebuilding reciprocal relationships with fish nations is a community priority. To further that priority, we used data from the Integrated Atmospheric Deposition Network, Great Lakes National Program Office, and Environment Climate Change Canada to evaluate the efficacy of Canada's 2008 PCB reduction policy. PCBs are a persistent organic pollutant present in atmospheric and fish tissue samples with known negative health effects to both fish and humans. Results indicate that local reductions of PCB stocks significantly reduced atmospheric PCB concentrations, but a comparable response was not seen in fish tissue. Fish tissue, as the primary exposure pathway for humans to PCBs, should be used to evaluate policy efficacy.

Vinayak Shedekar[1], Kevin King[2], Steven Lyon[1], Larry Brown[1], Norman Fausey[1, 2], Justin McBride[3] and Ben Reinhart[4], [1]The Ohio State University, [2]USDA Agricultural Research Service, [3]Ohio Department of Agriculture, [4]Ecosystem Services Exchange. **Future of water management strategies to reduce farm and watershed scale nutrient losses.**

Retaining and recycling water in the landscapes has been emphasized as a key strategy to protect the water quality in the Great Lakes Region. A well-designed and actively managed water management strategy has the potential to significantly reduce downstream water and nutrient discharges. The aim of this presentation is to inform and encourage adoption of smart water management strategies in the Domestic Action Plans. This work will review the 30+ years of research conducted in the Great Lakes and the Midwest regions on drainage water management practices that include controlled drainage, subirrigation, and the wetland reservoir subirrigation

(WRSIS) systems. We review the key findings from the historic research projects and sites, as well as key advancements in research focused on drainage water management. We will share some of the smart drainage management strategies implemented through case studies across Ohio, Minnesota, and Iowa. We will highlight the lessons learned from these studies, key knowledge gaps, and future direction for the research and action on smart drainage water management and recycling.

Lidi Shi[1], Mathew Wells[2], Binliang Lin[1] and Jian Sun Sun[1], [1]State Key Laboratory of Hydroscience and Engineering, Department of Hydraulic Engineering, Tsinghua University, [2]University of Toronto. **Flow Patterns and Water Mixing in a Reservoir-Regulated Confluence.**

Confluences are ubiquitous and important components in river systems, and their hydrodynamic complexity attracts increasing attention. The flow pattern in a confluence is influenced by planform geometry, momentum, discharge ratio and bed concordance/discordance. In recent years, confluence flow density is found to be a significant factor in flow patterns, while the generated hydrodynamic processes affecting water mixing are not fully known, especially in reservoir-regulated confluences. In this study, we investigate the hydro-thermodynamic processes at a large confluence in the Yangtze River using a 3D numerical model. Seasonal regulation by the Three Gorges Reservoir affects water levels within this zone. The results show that reservoir regulation significantly alters flow patterns in the confluence zone in both horizontal and vertical planes, including shrinking re-circulation, intricate cross-sectional vortexes, and weakened mixing capacity. Density difference leads to changes in the hydro-thermodynamic processes, especially when interacting with reservoir regulation. When the tributary water temperature is higher, the generated buoyancy strengthens the secondary flow in the mainstream, intensifying lateral transport and accelerating water mixing. Notably, the combined effect of reservoir regulation and thermal buoyancy alters the flow structure considerably in the confluence zone, and modifies the water transport mode in the mainstream. Thus, a dimensionless number S is defined to represent the lateral water transport capacity. These findings offer valuable insights into key processes in reservoir-regulated confluences, including water mixing, pollutant distributions, and aquatic habitat dynamics.

Wei Shi[1], Leon Boegman[1], Shiliang Shan[2], Yingming Zhao[3], Zachary Amindon[4], Josef Ackerman[5] and Edward Roseman[6], [1]Queen's University, [2]Royal Millitary College, [3]Ontario Ministry of Natural Resources and Forestry, [4]University of Toledo, [5]University of Guelph, [6]U.S. Geological Survey. **Earlier hatching affects the larval dispersal in Lake Erie.**

Pelagic larval dispersal is thought to be the main mechanism connecting many fishery populations and is an important determinant of individual success and population distribution and spatial structure. Quantitative estimates of larval dispersal from hatching grounds are thus important to understanding recruitment success in fisheries. The dispersal distance kernel (1D) and dispersal location kernel (2D), which give the probability that a larva will settle at a given distance from its hatching location, were applied to quantify larval dispersal patterns in western Lake Erie. We applied a forward Lagrangian particle tracking model, driven by a 3D hydrodynamic model and field data, to track larval trajectories of Lake Whitefish (*Coregonus clupeaformis*) and estimate larval dispersal distances and locations. Variability in hatch date was found to be the primary factor impacting the shape of the dispersal kernels. When larvae hatched earlier, they travelled faster but experienced colder water temperatures, slowing larval growth and resulting in a longer pelagic larval duration to achieve swimming ability at 17 mm length. The faster transport and longer pelagic larval duration caused the dispersal kernels to be shifted towards greater length scales, indicating that larval hatch date plays an important role in estimating larval dispersal patterns and studying population connectivity.

Narayan Shrestha, Nicole O'Brien and Frank Seglenieks, Environment and Climate Change Canada. **Developing Climate and Stochastic Sequences for GLAM Phase 2 Expediated Review.**

The freshwater resources of the Great Lakes and St. Lawrence River system are very important to the environment and economy of the U.S. and Canada. The Lake Ontario outflow at the Moses-Saunders Power Dam on the St. Lawrence River is regulated by Plan 2014. Due to repeated high flows in 2017 and 2019, members of public and elected officials questioned the functioning of the Plan 2014 in extreme conditions. As a result, the International Joint Commission (IJC) ordered an expedited review of Plan 2014. The completed phase 1 of the expedited review focused on the IJC's International Lake Ontario-St. Lawrence River Board (ILOSLRB) deviation decisions to extreme conditions. As such, the Phase 1 review considered a short forecast (6-month) and some more extreme water supply scenarios. Recently, the Phase 2 review has started with a broader scope of evaluating and ranking alternatives to Plan 2014 which requires a full range of possible water supply conditions including climate change projections. Here, we present water supply scenarios resulting from several bias-corrected Global and Regional Climate Model (GCM-RCM) combinations using a coupled hydrological model to serve as input to the evaluation of Plan 2014 and its alternatives. We also present stochastic water supply sequences for Lake Ontario in addition to stochastic discharge sequences downstream of the Moses-Saunders Power Dam.

Mike Shriberg, University of Michigan. **The Future of the Line 5 Oil Pipeline: Implications at the Climate/Water/Policy/Rights Nexus.**

The future of Enbridge Energy's Line 5 oil pipeline has become a defining issue for the future of the Great Lakes. It will set a critical precedent for reconciling energy choices with state's rights, water policy and Indigenous/First Nation rights. This session will outline the history of Line 5 with particular emphasis on how decision points have impacts far beyond the physical confines of the pipeline and potential spill areas. The session will assess how legal and political decisions about the future of Line 5 in the Straits of Mackinac and on the Bad River Band Reservation intersect with state regulatory authority, indigenous rights, and federal jurisdiction. In part because Line 5 will set a regional and national precedent for the future of fossil fuel infrastructure, national attention is focusing on this once local/regional debate. The session will outline the extraordinary story of how Line 5 went from being unknown to all but a few regulators to an issue of national importance with the potential to shape the region's future. A key part of this story is how oil spill science is being brought into the public sphere through governmental agencies and studies as well as non-governmental actors. The focus of the presentation will be assessing the implications of upcoming legal, policy and political decisions.

Mike Shriberg[1, 2] and Sara Hughes[1, 3], [1]University of Michigan, [2]Michigan Sea Grant, [3]RAND Corporation. **Great Lakes Restoration in a New Era of Challenges and Opportunities.**

We face a new era of challenges and opportunities in stewarding the Great Lakes. The management and policy regimes first developed over 100 years ago are ill-equipped to handle the complex, interrelated, generational problems confronting the Great Lakes region today. Fortunately, there is a generational opportunity right now to start toward true 21st-century stewardship because U.S. EPA is drafting a new Great Lakes restoration plan. To strengthen and reshape our institutions, policies and scientific inquiry, we need to create and apply a new set of Great Lakes stewardship principles based on boundary-spanning, justice and systems thinking. It is time to rethink institutions from the ground up, focusing especially on engaging communities meaningfully when generating new knowledge and making new policies. This will require support from Great Lakes decision-

makers at all levels as well as a groundswell of support from universities, non-governmental organizations and grassroots citizen movements. This presentation will examine emerging recommendations on interdisciplinary Great Lakes restoration through this lens of a new era of challenges and opportunities.

Mike Shriberg and **Silvia Newell**, University of Michigan. **Resourcing Coastal Resilience in Michigan.**

Michigan's Great Lakes coastal communities face an increasing set of climate change impacts that range from coastal flooding and increased severe weather to shoreline erosion due to variable lake levels. To respond to these complex and rapidly changing challenges, local governments and resource managers need to be well-informed and well-resourced. On November 2 & 3, 2023, Michigan Sea Grant (MISG) organized a workshop for over 50 coastal resilience managers and supporters, researchers, and state and federal employees to identify significant barriers to coastal resilience planning and to outline potential solutions (emphasizing nature-based approaches). The goal was to identify knowledge and resource gaps where training, funding, and technical assistance are needed and to brainstorm overarching structures for providing necessary support to coastal communities in Michigan and across the Great Lakes basin. The workshop was organized as a series of cross-sector conversations with guiding questions that began with identifying needs and barriers and concluded with the co-creation of potential solutions. This session would relay the results of and next steps from this workshop, which include recommendations for organizing communities of practice, meeting short-term assistance needs with planning and funding support, and creating a resource hub. Additional recommendations focus on expanding data and research and fostering education and communication. Feedback from the workshop is being used to develop a training curriculum on coastal resilience topics with an emphasis on environmental equity and justice.

Rose Simard and Catherine Febria, University of Windsor. **Riparian vegetational biodiversity and environmental gradients in Southern Ontario created wetlands.**

In response to the widespread loss and degradation of wetland habitats locally and globally, restoration efforts have included the creation of new wetlands. Despite being a common management practice, an understanding of the effectiveness of strategies such as pre-seeding with native species is needed. Here we explored vegetational composition and abundances across a gradient of created wetlands (n=10), measuring environmental variables in context of wetland age, seeding effort and location across Essex County and Pelee Island in July 2022. Surveys included triplicate transect and quadrat species-level biodiversity and a suite of environmental variables (i.e., slope, riparian width, soil moisture, soil composition, water quality). Data were analysed using multivariate statistics, exploring relationships within and across wetland size, age and region. Species characteristics were further investigated using SOFIA a local practitioner tool for assessing regional floral diversity. We found forbs and graminoids to dominate and older sites were characterized by denser overall vegetation cover. Approximate 75% of species were native across sites and species across all sites indicated floristic importance. Seeded sites differed from non-seeded sites in their species assemblages and on average 50% of seeded wetland species were recovered. Applied wetland restoration strategies appear to fostering restoration goals, notably increasing local biodiversity. This study provides a critical baseline and protocol for assessing local wetland ecosystems and future projects in the region.

Nitin Singh[1], Kimberly Van Meter[2] and Nandita Basu[1], [1]University of Waterloo, [2]Pennsylvania State University. **Pervasive increases in soluble phosphorus concentrations in streams across the transboundary Great Lakes Drainage Basin.**

Excess phosphorus from agricultural intensification have contributed to the eutrophication of rivers and lakes worldwide, including the transboundary Laurentian Great Lakes Basin. Algal blooms have surged in the past decade, threatening ecosystems, drinking water supplies, and lake dependent tourism economies in both large lakes (e.g., Lake Erie) and smaller waterbodies. While previous research has focused mainly on phosphorus loads to Lake Erie, a comprehensive analysis of phosphorus species across the basin is lacking. Here we analyze changes in soluble phosphorus and total phosphorus in over 350 watersheds across the Great Lakes Basin from 2003 to 2019. We find widespread increases in soluble phosphorus concentrations (83% of watersheds, with 46% showing significant increase), while total phosphorus concentrations are decreasing or non-significant. Utilizing, random forest models, we identify small, forested watersheds at higher latitudes as the areas experiencing the largest relative increases in soluble phosphorus concentrations. Furthermore, we find winter temperatures to be a key driver o winter concentrations trends. We propose that the increase soluble phosphorus concentrations across the basin, along with warming temperatures, might be contributing to the increasing frequency and intensity of algal blooms, emphasizing the need for management strategies to prevent further water quality degradation.

Shweta Singh[1], Dienye Tolofari[2], Carol Miller[1], Yongli Wager[1] and John Norton[2], [1]Wayne State University, [2]Great Lakes Water Authority. **University/Utility Collaboration for Advances in Great Lakes Drinking Water Research.**

The use of pilot plant is an excellent way to mimic and understand the treatment processes of a full-scale drinking water treatment facility. Pilot plant operation allows researchers and city water managers to test various water treatment processes affecting water quality. This presentation highlights the calibration and validation of pilot plant as a predictive model of a major full-scale treatment plant behavior in the Great Lakes region. The ongoing research addresses various scale-up challenges, optimization of current drinking water treatment strategies, tests for specific water conditions, and evaluation of emerging water quality concerns.

Katherine Skubik, Tracey Galarowicz, Jason Smith, Jory Jonas, Kevin Pangle and Gary Michaud, Little Traverse Bay Bands of Odawa Indians. **Helping Otoonapi (Cisco, *Coregonus artedi*) using Geometric Morphometrics.**

Otoonapi, (Cisco, *Coregonus artedi*) are a highly plastic and culturally important species with diverse morphology and unresolved morphometric interpretation. Understanding basic Otoonapii life history generally, and this plasticity specifically, is critical to the future of Otoonapii in the Great Lakes. We chose to analyze morphometry from three collections of fish originating in Lakes Huron, Michigan and Superior. First, we compared historic and current morphometry of wild fish from each lake (n=731). Second, we compared morphometry of fish from all three lakes raised under common garden conditions (n=63). We used a homologous landmarking scheme with sixteen landmarks and digitized images of mature Otoonapi from each group. We identified unique allometries among groups with a predicted shape on size regression. In the historic/current analysis, a MANOVA showed centroid size, group, and the interaction between the two are significant ($p<0.05$) for allometry. For the common garden, we conducted an ANOVA for morphological disparity with pairwise comparisons to evaluate shape. This test shows there is no statistical difference in morphology among lakes for common garden experiment Otoonapi. PCA descriptions

of shape variable residuals and warped outline drawings are used to illustrate the lack of morphological variation between common garden Otoonapi from different lakes.

DJ Smith[1], Jason Smith[2] and Rusty Aikens[1], [1]Sault Ste Marie Tribe of Chippewa Indians Fisheries, [2]Bay Mills Biological Services. **Translocation: A Means to Re-establishing Tributary Spawning Lake Whitefish.**

Translocation of fish species has been used for hundreds of years to spread desirable species into areas they were not previously found. Recently, it has become a vital tool for fishery managers to protect and maintain populations and genetics of threatened species. The movement of fish around barriers such as dams to new or unused habitat has also become very popular and successful. Due to dams, habitat destruction and pollution, many fish species including Lake Whitefish *Coregonus clupeformis,* lost tributary spawning runs. Within the last few years, Lake Whitefish have been found spawning in Green Bay tributaries once again after a 100-year extirpation. In the fall of 2023, we placed 11 female and 22 male Lake Whitefish into a raceway that contained a mock spawning area and egg mats spread throughout. In late December, eggs collected from the egg mats were placed into an incubation system where several developed to eye up. For 2024, our goal is to PIT tag at least 25 pairs of gravid Lake Whitefish and release into the upper section of the Carp River, a Lake Huron tributary. We will use pass-through antennas to track adult fish and a combination of egg mats and larval drift to evaluate possible spawning. The goal of this study is to determine the viability of translocation as a way to create a tributary spawning population of Lake Whitefish.

Erin Smith, St. Lawrence River Institute of Environmental Science. **Long-term nutrient trends in the Upper St. Lawrence River: Implications for the Great Lakes Basin.**

The St. Lawrence River is the last waterway in the Great Lakes system, and as such its water quality reflects upstream inputs. The Upper St. Lawrence River (USLR) has experienced a variety of anthropogenic stressors, including pollution from industrial activities along its shorelines, establishment of invasive species, and land use change. As such, an updated analysis of nutrients (nitrogen and phosphorus) is required to understand the temporal and spatial trends within the USLR. A systematic literature search was conducted to identify and request data from academic and government sources. Once received, data was cleaned and synthesized for statistical analysis. Generalized additive models (GAMs) were built to examine the temporal and spatial trends and identify potential explanatory variables. We found a significant effect of invasive dreissenid mussels and precipitation on nutrients in the USLR. These findings provide evidence of broader nutrient trends in the Great Lakes and indicate a continued impact of dreissenid mussels on nutrients in the system. The trends identified in this analysis provide new insights that should be considered for future policy decisions regarding nutrient management of the Great Lakes.

Ian Smith, University of Toronto Scarborough, Department of Physical & Environmental Sciences. **The Use of Low-Cost Aerial Drone Systems in Coastal/Fluvial Geomorphic Assessments and Habitat Design.**

Topographic and bathymetric surveys are useful tools in coastal and fluvial geomorphology workflows for aquatic habitat design. 3D data are critical for the analysis of lentic and lotic systems, and the creation/restoration of shoreline and riparian habitat across space and time. Surveys of watercourses and waterbodies are used to measure rates of geomorphic change and over time. Traditionally, survey methods have made use of low-tech equipment including dumpy levels or theodolites that require in-situ access to waterbodies and watercourses. These tools are time-consuming to use and require added personnel to safely support the collection of hydrographic data.

Until recently, aerial surveys have been expensive. With the use of autonomous Remotely Piloted Aerial Systems (RPAS, aka drones), aerial surveys have become less expensive, faster, while deriving denser spatial datasets. Often, field surveys that once took days to complete can be undertaken in mere hours with a single RPAS operator. Safety is enhanced by removing the need to enter flowing or deeper water systems. Similarly, limitations of drones in the past have included their inability to survey underwater topography/shallow bathymetry. Recent advancements in RPAS, aerial camera technology, and post processing image analysis software have allowed for the rapid and logistically simple inclusion of bathymetric data within fluvial and nearshore coastal analyses. The use of inexpensive RPAS to complete surveys in and around watercourses and coastal areas is highlighted via specific project examples.

Stephanie Smith, Ted Lawrence and Zeph Migeni, African Center for Aquatic Research and Education. **Collaborative approaches and actionable solutions for the transboundary African Great Lakes.**

The African Great Lakes are of vital importance to hundreds of millions of people, to whom they provide drinking water, food, jobs, and transportation. These East African lakes support the economies of their ten riparian countries and are among the most species-rich freshwater systems on the planet, harboring over a thousand fish species, and hundreds of other aquatic and terrestrial species. While vitally important, they face complex anthropogenic stressors akin to many other global lakes, including climate change, overuse, gas and oil exploration, habitat loss and degradation, agricultural runoff, industrial and urban pollution, and invasive species. To make sound policy and management decisions, these multi-jurisdictional lakes require collaborative, problem-solving approaches for improved health. Addressing African Great Lakes freshwater challenges requires strategies that include knowledge-sharing and partnerships across the lakes and around the world. When scientists and communities leverage the combined skills and resources of public, private and nonprofit entities to deliver ecosystem-wide solutions, they can positively influence policy and management of freshwater resources in East Africa through long-term, coordinated approaches. The collaborative process underway in the region, described in this talk, works to ensure improved ecological health of the African Great Lakes for those who depend on them through sound science and building knowledge and solutions with global partners.

Ryan J. Sorichetti, Nadine Benoit, Bogdan Hlevca and Todd Howell, Ontario Ministry of the Environment, Conservation and Parks. **Insights from a seasonal nearshore water quality survey in the western basin of Lake Ontario.**

The Ontario Ministry of the Environment, Conservation and Parks conducted a nearshore water quality assessment in the western basin of Lake Ontario during the ice-free season of 2023. Lake Ontario shoreline around the Golden Horseshoe between Oakville and Grimsby is currently experiencing rapid urban development, industrial pressures, and changes in climatic forcings. This multi-faceted synoptic mapping survey focused on nearshore areas, between the shoreline and up to 5 km offshore, where lake water quality is expected to be most impacted by landscape activity. The aim of this study is to broadly characterize the spatial and seasonal features of water quality as it relates to shoreline features and the physical conditions of nearshore lake waters. This presentation will share seasonal observations and highlights from detailed surface water mapping, report on nutrient chemistry and productivity to indicate water quality status and discuss some of the novel weather and lake physical forcings that were observed to have a predominant impact on nearshore water quality. Results will also be framed in the context of contributions to hydrodynamic modeling efforts that will be better equipped to integrate lake physical process and impacts of dynamic

onshore and offshore gradients. Insights on the status of nearshore water quality in the western basin of Lake Ontario are required to best manage future development and climate impacts and can be compared to other developing nearshore areas experiencing similar pressures.

Jacob Soter and Andrew Barnard, SwimSmart Technology LLC. **Closed Loop Forecasting within a Nearshore Safety Framework.**

Addressing the challenges of comprehensive observations in the Great Lakes nearshore zones requires innovative approaches to optimize resources and promote community engagement. This presentation explores the synergies between swimmer notification systems and scientific observation platforms to encourage municipalities to take proactive ownership of beachfront safety. The integration of Internet-of-Things (IoT) observation devices into a smart, connected platform technology, exemplified by the SwimSmart warning system, is examined. This approach not only enhances swim safety management but also presents numerous benefits to the scientific community in an economically feasible manner. The presentation delves into the potential for dramatic improvements in nearshore forecasting, and other scientific endeavors, through coastal observations. The capital-intensive nature of rolling out observational infrastructure, primarily involving common IoT components such as telemetry, power, and computation, is acknowledged. By consolidating nearshore forecasting with safety infrastructure, the financial burden is shared among multiple stakeholders, facilitating mass adoption at the local level. The proximity of safety infrastructure to high-risk areas, and necessity of minimal downtime, positions onboard observing systems at the heart of the problem, ensuring timely and relevant data collection. Standardized observational tools, coupled with edge processing and warning systems, pave the way for continuously improving closed-loop forecasts. A case study is proposed to serve as a benchmark for future enhancements, showcasing the potential of this integrated approach for advancing coastal resilience and safety.

Elizabeth Spitzer, Liane Rosario, C. Robin Mattheus and Kristen Pearce, Illinois State Geological Survey. **Storm Impacts on Coastal Geomorphology & Stratigraphy: Topographic and GPR Assessment, Illinois Beach, Lake Michigan.**

Lake Michigan beaches experience sediment movement in alongshore and cross-shore directions during storms due to winds, waves, currents, and surges. Despite our conceptual understanding of storm-induced geomorphic changes from topographic assessments, an integrated approach with subsurface data may enhance our understanding. Subsurface manifestations of processes occurring during multi-day storm events may exist that go unrecognized in topographic assessments. In October 2023, a SW Lake Michigan beach in Zion, Illinois, was surveyed pre- and post-storm using aerial drones (for Structure from Motion Photogrammetry), concurrent with 200 MHz ground-penetrating radar (GPR) imagery of the subsurface. The study aimed to (1) detect surficial changes and subsurface evidence of a multi-day storm event; and (2) evaluate the added utility of subsurface imagery in studying storm-induced geomorphic changes. The event was linked to local onshore winds of up to 12 m/s and wave heights of up to 3.2 m. These conditions resulted in foreshore-elevation losses of up to ~0.7 m and shoreline recession of up to 14 m along the areas surveyed. Topographic datasets alone overlook the deposition of ~0.4 m of sand atop a storm-ravinement surface, recognized from pre- and post-storm GPR imagery. This indicates that while net erosion occurred, there was a period of deposition associated with the event. While topographic assessments are useful, integration with subsurface data paints a more complete picture of event morphodynamics.

Joseph Salerno[1], **Katie Stammler**[2], Tracie Greenberg[1] and Darryl McGoldrick[1], [1]Environment and Climate Change Canada, [2]Essex Region Conservation Authority. **A Comparison of Nutrient Load Estimates between the Leamington Tributaries, Thames River, and Sydenham River (2018-2022).**

Harmful algal blooms are an annual occurrence in Lake St. Clair and the western basin of Lake Erie. In 2018, Domestic Action Plans were released to aid in the 40% reduction of phosphorus to Lake Erie, focusing on priority watersheds including the Leamington Tributaries. These relatively small watersheds in the municipalities of Leamington and Kingsville (Essex County, Ontario) drain into Lake Erie's western basin, and are heavily influenced by greenhouse agriculture. Previous studies showed that total phosphorus (TP) concentrations in this area were typical of similar agricultural streams prior to 1996. Following rapid growth of the greenhouse sector, TP concentrations have been substantially and consistently higher than nearby agricultural streams. In this study, TP loads and flow-weighted-mean concentrations for the Leamington Tributaries were assessed from 2018 to 2022. Loading estimates were also compared to the other priority watersheds (Thames River and Sydenham River) to understand the Leamington Tributaries' TP contribution to Lake Erie. Updated TP loads will be presented for the Thames River, Sydenham River, and Leamington Tributaries (monitored and unmonitored) based on calculations from Environment and Climate Change Canada's Erie Loading Tool (V1.4), which uses the Stratified Beale Estimator method. Unique challenges that face all three watersheds will be addressed, highlighting efforts made by local conservation groups and stakeholders to reduce phosphorus. Importantly, this work is a collaborative effort between local Conservation Authorities, and Federal and Provincial scientists.

Ashlyn L. Stanalonis[1], Kayla C. Gonzalez-Boy[1], George S. Bullerjahn[2], Christopher S. Ward[2], Troy R. Mutchler[1] and Mark J. McCarthy[1, 3], [1]Department of Ecology, Evolution, and Organismal Biology, Kennesaw State University, Kennesaw, GA 30144, USA, [2]Department of Biological Sciences, Bowling Green State University, Bowling Green, OH 43403, USA, [3]Chair of Hydrobiology & Fisheries, Estonian University of Life Sciences, Tartu, 51006, Estonia. **Determining the Role of Maumee River Sediments in Microbial Nitrogen Transformations and Net Fluxes.**

Fertilizer runoff is a major source of excess nutrient loading to river systems in agricultural watersheds, and total nitrogen (N) and phosphorus (P) inputs contribute to eutrophication and cyanobacterial blooms. This study aims to identify Maumee River sediments as net N sinks or sources to the western basin of Lake Erie and evaluate N removal efficiency (a valuable ecosystem service) to determine if river sediments alleviate or worsen eutrophication. Water samples and intact sediment cores were collected from four sites along the river and used in a continuous-flow incubation system. Inflow reservoirs were spiked with ^{15}N-labeled ammonium or nitrate, and samples collected during incubations were used to determine net nutrient and dissolved gas (N_2 and O_2) fluxes. Preliminary results suggest that Maumee River sediments are a consistent source of ammonium, and occasional source of urea and ortho-phosphate, to the river water column, with high ammonium-to-phosphate efflux ratios (> 20). Sediments also exhibited consistent N_2 gas effluxes, representing a valuable N sink. Downstream sediments were more likely to be a net N source to the overlying water column, while upstream sediments were usually a net N sink. These results illustrate the potential for river sediments to modify, delay, and/or remove external N loading sourced from the watershed and show that further efforts should be aimed to reduce these external N loads in addition to current efforts to reduce P loads.

Keara Stanislawczyk[1], Natalie M. Dugan[1], Amber A. Beecher[2], Brenda K. Snyder[2], Thomas B. Bridgeman[2] and Justin D. Chaffin[1], [1]F.T. Stone Laboratory and Ohio Sea Grant, The Ohio State University, Put in Bay, Ohio 43456, USA, [2]Lake Erie Center, The University of Toledo, Oregon, Ohio 43616, USA. **Cyanobacterial growth and microcystin toxin production in Lake Erie's western basin.**

Microcystin toxins created by cyanobacteria are a major threat to both the environment and to human health in Lake Erie's western basin. Many researchers use grab samples to detect microcystins in the lake, however, it is difficult to predict future microcystin concentrations by solely using data from grab samples. Understanding cyanobacterial growth rates, microcystin production rates, and what drives them will be crucial to creating a Lake Erie microcystin forecast to minimize our exposure to the toxins and understand how management actions may affect future blooms' biomass and toxicity. In 2023, we sampled several sites throughout Lake Erie's western basin and Maumee Bay and monitored the microcystin production rates and cyanobacteria growth rates using laboratory experiments with ambient conditions and elevated phosphorus and nitrogen (P&N). Production and growth rates in the P&N enrichment were greater than the ambient nutrient controls indicating nutrient limitations throughout the 2023 growing season. The highest microcystin production rates were measured during July (average across all sites 0.16±0.04/d), and decreased throughout the season (0.12±0.09/d in August; 0.07±0.07/d in September). We observed this temporal pattern in previous years. The only spatial pattern observed was the ambient nutrient controls had highest production rates at sites closest to the Maumee River. We will continue monitoring microcystin production and growth rates for the 2024 and 2025 growing seasons.

Damon Stanwell-Smith[1], **Kimberly Galvez**[1], Meghan Goggins[1], Jason Hayden[1], Brandi Revels[1] and Richard Bates[2], [1]Viking, [2]St Andrews University, UK. **Innovative research and monitoring through the collaboration between NOAA / GLERL and Viking Expeditions.**

In 2019 the Norwegian cruise line, Viking, designed and then built two bespoke polar class expedition cruise vessels - *Viking Octantis* and *Viking Polaris* - with unprecedented research capacity onboard for vessels of this type. Significantly they were also designed to fit through the Welland Canal so that they can operate in the Great Lakes in summer seasons. An innovative collaborative research program was established in parallel, most pertinently to this audience with NOAA / GLERL, the University of Windsor / GLIER and the Georgian Bay Biosphere Reserve; as well as Cornell Lab of Ornithology, Scripps Institution of Oceanography and select others. Please join Dr Damon Stanwell-Smith, Viking's Head of Science and Sustainability and Dr Kimberly Galvez, Chief Scientist of the *Viking Octantis*, as they present an overview of how these remarkable vessels were completed during the pandemic, their research capacity and equipment; and how Viking's science program is structured and has evolved. They will share what oceanographic research and opportunistic environmental monitoring has been currently undertaken since they started operating in the Great Lakes in 2022 - and the exciting possibilities for future collaborative Great Lakes research.

Isabelle Staph[1, 2], Stuart Carlton[1, 2] and Zhao Ma[2], [1]Illinois-Indiana Sea Grant, [2]Purdue University Department of Forestry and Natural Resources. **Community perceptions of remediation, restoration, and revitalization in the Great Lakes Areas of Concern (AOCs).**

The importance of public input is increasingly recognized in the restoration of contaminated communities. Opening the decision-making process to the public allows for a wider representation of interests regarding changes being made to the community and is a vital component to successful restoration and revitalization. Over the last 50 years, the Great Lakes Areas of Concern (AOCs)

have undergone remediation and restoration of contaminated waterbodies and their surrounding area to improve environmental, social, and economic conditions. Though public input is typically sought out in these projects, it is common for many people and groups within a community to be uninvolved. This is observed in many AOCs, including the Grand Calumet River and the Waukegan Harbor AOCs. Both AOCs have undergone decades of remediation and restoration and are starting to show initial indicators of revitalization. As opportunities for community revitalization increase, it is important to understand the community's role in this process. Our research examines community perceptions of revitalization, as well as the motivators and barriers in place for the public to be involved in the overall remediation, restoration, and revitalization framework. Our results shed light on the importance of representation and trust in community participation and how revitalization is perceived by members of the community, as well as if revitalization indicators align with community interest in the Grand Calumet River and Waukegan Harbor AOCs.

Robert Stewart, Timothy Hollinger and Nathan Wilson, Lakehead University. **Is Lake Nipigon Part of Great Lakes Management? Community-Based Monitoring and Governance Opportunities in the Lake Superior Basin.**

The paper provides an overview of community-based monitoring efforts that are taking place on the Canadian side of the Lake Superior Basin and explores how community empowerment and local knowledge can contribute to broader lakewide management through knowledge mobilization and co-management principles. Case studies focus on Lake Nipigon and the North Shore of Lake Superior with a particular interest in First Nations communities who are currently engaged in monitoring contaminants and protecting their traditional lands. The goal of the session is to explore the potential relationships and pathways that can lead to enhanced capacity for First Nations to engage in Great Lakes governance.

Wendylee Stott[1], Chris Wilson[2], Mark Ridgway[2], Yue Shi[3], Peter Euclid[4] and Wesley Larson[5], [1]Fisheries and Oceans Canada, [2]Ontario Ministry of Natural Resources & Forestry, [3]University of Alaska Fairbanks, [4]Purdue University, [5]National Oceanic and Atmospheric Administration.
Genomic Diversity of Lake Whitefish *(Coregonus clupeaformis)* from Algonquin Park.

Coregonines are well known for ecomorphotypic variation across their range. Ecomorphotypic variation is based on many features including size, gill raker counts, and depth distribution. The presence of ecomorphtypes can make management challenging in fisheries and in nature preserves that allow sport fishing. Several lakes in Algonquin Park support Lake Whitefish ecomorphotypes that differ in size and habitat use, but it is not clear if these differences are the result of post-glacial colonization, recent evolution, and/or past stocking events. We explored the use of a of a genotyping-in-thousands by sequencing panel developed for Great Lakes Lake Whitefish to quantify genomic differences among and within lakes. Seven lakes in Algonquin Park and Lake Simcoe were sampled to determine if there are any genetic differences among lakes and ecomorphotypes. More than 300 of the loci in the panel were sequenced in most samples. Each lake was genetically distinct over all analytical methods used and additional structure was identified within Big Trout Lake and Lake Opeongo. In Big Trout Lake, two genetic groups were associated with Lake Whitefish that differed in size and habitat use. In contrast, all fish from Lake Opeongo in each group were a similar size and were caught at similar depths.

Wendylee Stott, Lauren Wiens, Muhammad Janjua, Brendan Malley, Kim Howland and Ross Tallman, Fisheries and Oceans Canada. **Development of Genomic Resources for Monitoring Inconnu Diversity and Harvest *(Stenodus leucichthys).***

Inconnu are found in Arctic rivers and lakes in north-western North American and Eurasia. They are a large, piscivorous coregonine that, similar to other coregonines, exhibit variation in life history across their range. Anadromous Inconnu may migrate hundreds of kilometers to spawn in rivers such as the Yukon River while others are potamodromous, remain in freshwater systems like Great Slave Lake, exhibit site fidelity to natal spawning grounds, and move to tributary rivers in fall. In Great Slave Lake in the Northwest Territories, Inconnu are generally caught as by-catch in commercial fisheries although targeted fisheries are becoming more common. As the nature of the fisheries have changed, there have been population declines in some areas of Great Slave Lake which has raised concerns among fishers, local communities and managers about the long-term sustainability of the fisheries. Efforts are underway to better understand the current extent of Inconnu populations, stresses on different populations, and how they are utilized by different fisheries. Several methods, including genetics, are being used to define population boundaries, estimate contributions of populations to fisheries, and model impacts of climate change. Recent advances in next-generation sequencing technology can provide tools to accurately measure the sources of mixed fisheries. In this project, we describe how genomics is contributing to our understanding and management of Inconnu in Great Slave Lake.

Craig Stow[1], Eric J. Anderson[2], Andrew Gronewold[3], Lacey Mason[1], Song Qian[4], Steve Ruberg[1], Kyle Beadle[1] and Stephen Constant[1], [1]NOAA Great Lakes Environmental Research Laboratory, [2]Colorado School of Mines, [3]University of Michigan School for Environment and Sustainability, [4]University of Toledo. **Long-Term Temperature Monitoring in Lake Michigan.**

Since 1990 the NOAA Great Lake Environmental Research Laboratory has maintained a mooring in southern Lake Michigan (depth ~150 m), which has recorded temperature throughout the water column at sub-daily intervals. This unique data set provides precise measurements of the timing of fall overturn, the point of minimum temperature, and the duration of the winter cooling period. Surface warming rate estimates range from 0.40 - 0.49 °C/decade, depending on the analysis method, while rates at 110 m depth range from 0.04 - 0.06 °C/decade; no discernible increase occurs at greater depths. At the surface, warming trends in September and October indicate an extended period of stratification, while at 110 m destratification has been delayed from late November - early January, upwards of six weeks. If these trends persist, a possible shift from a dimictic to monomictic regime could occur, with a lengthy summer stratification period punctuated by an extending mixing period in the cooler months. Even without such a shift, the effects of delayed stratification and warmer temperatures on the physics, chemistry, and biology of the lake invite further exploration.

Craig Stow[1], Erin Bertke[2], Cal Buelo[3], Mary Anne Evans[4], Rob Hyde[5] and Claire Penstone[5], [1]NOAA Great Lakes Environmental Research Laboratory, [2]U.S. Geological Survey, Ohio-Kentucky-Indiana Water Science Center, [3]U.S. Environmental Protection Agency, Great Lakes National Program Office, [4]U.S. Geological Survey, Great Lakes Science Center, [5]Environment and Climate Change Canada, Canada Water Agency Branch. **Adaptive Management of Nutrient Loading to Lake Erie: Binational Evaluation for 2017 - 2021.**

Under the 2012 Great Lakes Water Quality Agreement (GLWQA), Canada and the United States are using an Adaptive Management (AM) approach for addressing eutrophication issues in Lake Erie. AM seeks to maximize learning and reduce uncertainty by constructing hypotheses

regarding the expected ecosystem response that guides monitoring, modeling, and research, the results of which inform future management actions. As part of the AM approach, the GLWQA Annex 4 (Nutrients) Subcommittee committed to conduct an evaluation every 5 years to assess changes in phosphorus loads and progress towards achieving Lake Ecosystem Objectives and make recommendations for improving AM efforts. The first evaluation was conducted for the 2017-2021 period using information and expertise from federal, provincial/state, and local agencies, and academic partners. During this 5-year period, assessment of phosphorus loading found that established loading targets were rarely met, load reductions were difficult to discern, and loads continue to be largely driven by tributary discharge. Eutrophic conditions and harmful algal bloom biomass exceeded desired levels in the western basin. In the central basin, the August-September hypolimnetic dissolved oxygen desired level was met in 3 of the 5 years. Nuisance benthic algae biomass was highly variable from year-to-year and often above nuisance levels in shallow eastern basin sites. This evaluation serves as a baseline for tracking future progress and will inform domestic strategies and actions to manage nutrient loads to Lake Erie.

Rochelle Sturtevant[1] and Ashley Elgin[2], [1]Michigan Sea Grant, [2]NOAA Great Lakes Environmental Research Laboratory. **Laurentian Great Lakes Horizon Scanning for Aquatic Invasive Species.**

As the number of introduced non-native species continues to increase, identifying and prioritizing current and potential threats has become essential to management. Global, national, regional and state/provincial assessments all collate critical information relevant to understanding the potential threat of non-native species to the Laurentian Great Lakes. Beginning in 2021, GLANSIS developed a risk assessment clearinghouse (https://www.glerl.noaa.gov/glansis/riskAssessment.html) at the request of regional management agencies. With input from the Great Lakes Panel on Aquatic Nuisance Species, a subset of 16 risk assessments and horizon scans were selected for inclusion that encompass a breadth of geographic scales (from global to state-specific), collectively cover the full range of taxonomic diversity (though not unbiased), and use a diversity of methods (from expert opinion to quantitative analysis of species traits). The 'Species Results Explorer' feature of the Risk Clearinghouse, contains brief summaries of the assessment/scan result for each species included in the assessment results for each of these methods. Collectively, these 4907 individual assessments encompass 3072 species (many species were evaluated by multiple methods). A rapid screening was applied to each species which removed 71% from consideration that were low risk to the Great Lakes or otherwise did not match previously established GLANSIS listing criteria. A subset of the remaining species were subjected to a more extensive literature review which resulted in 12% (15 of 128) meeting criteria for GLANSIS listing.

Amanda Suchy[1], Casey Godwin[2] and Donald Uzarski[1], [1]Central Michigan University, [2]University of Michigan. **Patterns of greenhouse gas concentrations in coastal wetlands of the Laurentian Great Lakes.**

Coastal wetlands can act as hotspots of greenhouse gas (GHG) emissions due to their high productivity and anthropogenic impacts. The Laurentian Great Lakes, one of the largest bodies of surface freshwater, has very few comprehensive measurements of GHG emissions from their associated wetlands. We leveraged the Coastal Wetlands Monitoring Program to collect data on dissolved GHG concentrations in 67 wetlands across the Great Lakes Basin in summer 2023. Samples were collected from the open water environment and 1-3 vegetation zones within each wetland. Dissolved gasses were extracted from water samples on site and later analyzed for CO_2, CH_4, and N_2O concentrations. Results are reported as the observed gas concentration divided by the

expected gas concentration if the water was at atmospheric equilibrium. We found CH_4 concentrations were greater than atmospheric equilibrium in all samples ranging from 192x expected CH_4 at atmospheric equilibrium to greater than 36,000x the expected concentration. CO_2 and N_2O concentrations ranged from near equilibrium values to 54x and 10x the expected concentrations, respectively. Vegetated patches had higher CO_2concentrations than open water, while open water had higher N_2O concentrations than vegetated patches. Additionally, vegetated patches had increasing CH_4 concentrations with decreasing human impact, while N_2O concentrations decreased with decreasing human impact. These data demonstrate Great Lakes coastal wetlands can generate substantial GHG emissions, and thus further investigations to the mechanisms driving GHG emissions is warranted.

Zach Swan[1], Greg Cutrell[2], Luke Skowronek[1], Ishfaq Rahman[1], Raissa Mendonca[3], Laura Johnson[4], Lauren Kinsman-Costello[3] and Thomas Bridgeman[1], [1]University of Toledo, [2]LimnoTech, [3]Kent State University, [4]Heidelberg University. **Capitalizing on the Capabilities of Sensor Network Systems in H2Ohio Wetlands.**

The H2Ohio Wetland Monitoring Program is a collaborative effort aiming to assess wetlands' capability to mitigate nutrient runoff that would otherwise reach Lake Erie and exacerbate Harmful Algal Blooms (HABs) in the Western Basin of Lake Erie. However, the frequency of data collection across a large number of wetlands required to adequately assess wetland performance poses a number of logistical challenges, especially related to rapidly changing water levels, local meteorological conditions, and access during inclement weather. LoRaWAN (Long Range Wireless Access Networks) and cellular networks can be utilized in conjunction with compatible environmental sensors to relay live data at a high frequency and help meet data challenges. The H2Ohio Wetland Monitoring Program has installed five customized sensor network systems that monitor six separate H2Ohio projects at 10 minute intervals and transmit data live including meteorological data, water level, soil moisture, and water quality (temperature, conductivity, turbidity, dissolved oxygen, and pH). These networks have bolstered the program's understanding of how each of these wetlands function and can be used to inform researchers of crucial times to collect samples (i.e., after a storm in the area). These Sensor Network Systems have become a pivotal part of the H2Ohio Wetland Monitoring Program and have demonstrated the ability to be a valuable asset to other environmental programs in the future

Aubree Szczepanski[1], Anett Trebitz[2], Joel Hoffman[2], Chelsea Hatzenbuhler[3], Greg Peterson[2] and Courtney Larson[2], [1]Oak Ridge Institute for Science and Education Intern at the U.S. Environmental Protection Agency, [2]U.S. Environmental Protection Agency, [3]SpecPro Professional Services Contractor. ***Dreissena*** **composition and distribution in Lake Superior.**

Dreissena are an invasive genus of mussels having a planktonic early life stage (veligers) which is passively transported by currents. There are two species in the genus, zebra (*D. polymorpha*) and quagga (*D. bugensis*), with zebra being generally more inshore/littoral and quagga more offshore/profundal. Bottom-settled *Dreissena* are established in the lower Great Lakes but known colonies are still geographically very restricted in Lake Superior. Recent advances in PCR (polymerase chain reaction) techniques permit searching for veligers (or DNA) in zooplankton samples with greater sensitivity and species-level resolution compared to conventional microscopy enumeration. We applied PCR analyses to the ethanol preservative from zooplankton tows collected during the 2022 Lake Superior Cooperative Science and Monitoring Initiative, generating data for 56 offshore (153 and 64µm tows) and 75 nearshore (153µm tows) stations. Veliger enumeration data are available for the 64µm samples, and all samples have supporting water quality data. qPCR

detected zebra DNA in 21 samples with occurrences generally to the north and west side of the lake and DNA copy number peaks offshore of known adult populations, while quagga DNA was detected in 56 samples generally to the south and east side of the lake and a peak far from known populations. We will discuss these spatial patterns, possibility of veliger survival and settlement, relationships to adult populations, and implications for prevention and management of *Dreissena* in Lake Superior.

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Samantha Tank[1], Theresa Gruninger[1], Taaja Tucker-Silva[1], Nichole Angell[1], Erika Jensen[1], Chuck Bargeron[2] and Kurt Kowalski[3], [1]Great Lakes Commission, [2]University of Georgia, [3]U.S. Geological Survey. **The Phragmites Adaptive Management Framework: Implementation and refinement from 2017 - present.**

Common reed (*Phragmites australis*) is one of the most prevalent plant invaders in North America, and its removal requires significant cost and time investments by natural resource managers in the Great Lakes region. While there are myriad ways to manage *Phragmites*, a specific set of best management practices does not yet exist. In 2017, the Great Lakes *Phragmites* Collaborative established a participatory science program, the *Phragmites* Adaptive Management Framework (PAMF), to determine the most effective and cost-efficient ways to manage *Phragmites*. PAMF operates on an annual adaptive management cycle whereby the participants collect and submit monitoring and management data to inform the PAMF predictive model, which in turn produces site-specific management guidance for participants based on the latest information about which techniques are working most efficiently and effectively to reduce *Phragmites* invasion. PAMF is open to managers within the eight Great Lakes states and two Canadian provinces. Although in its seventh annual cycle with numerous programmatic and technical updates, PAMF has yet to undergo formal double loop learning mainly due to a lack of critical model data. To speed up model learning, PAMF is entering a new "active adaptive management" phase of learning where managers will receive funding to implement targeted management combinations that are underrepresented within the model. This presentation will cover the development, implementation, and refinement of PAMF, a participatory science meets adaptive management program.

Grayson Tellier, University of Windsor. **Determining the effect of senescence on sperm quality and reproductive success in Chinook salmon.**

Reproductive senescence is defined as the progressive degradation of reproductive cells (i.e., sperm cells), potentially leading to declines in fertility and reductions in fitness. This process can occur to either the somatic cells that produce reproductive cells, or to the reproductive cell itself after production. Chinook salmon are semelparous, meaning they spawn once and undergo rapid aging and deterioration during their short reproductive season before dying. This presents a unique opportunity to understand reproductive senescence in nature and its impact on reproductive ability. To test whether sperm quality and fertility decrease as Chinook senesce during their reproductive season, wild males were sampled and categorized based on their degree of apparent senescing. I then measured their body conditions and collected a sperm sample. Sperm quality was determined by testing and analyzing each sample for traits related to reproductive success. I also used sperm samples to fertilize eggs to assess the effects of sperm ageing on hatching success. The development of the resulting offspring was also measured to determine if there exists a relationship between reproductive senesce and offspring quality. Chinook salmon face a variety of threats and rely on

captive breeding efforts to support declining wild populations. This research not only directly influences conservation policies for Chinook, but it also provides insights into evolutionary aspects of aging, fertility, and parental effects, that may extend to other species that reproduce similarly.

André Temgoua, Frank Seglenieks and Kevin Weng, ECCC National Hydrological Service.
Enhancing Hydroclimate Data Quality: BWIU Advances in Machine Learning.

The Great Lakes Basin, a pivotal region for hydroclimate data, encounters significant challenges related to data quality and reliability. This study addresses these challenges by leveraging advanced machine learning techniques to detect and correct uncertainties in the processing of hydroclimate data. Data analysis is crucial for understanding physical processes and model outcomes since it's susceptible to various sources of uncertainty. Properly identifying and rectifying these uncertainties is paramount to prevent biased analyses and erroneous decision-making. This study involves employing machine learning algorithms to systematically identify inaccuracies and errors in data processing. The outcomes of this work are two-fold. First, the application of machine learning algorithms results in notable improvements in performance metrics for both traditional and machine learning models. Second, the enhanced reliability and accuracy of the results instill greater confidence among practitioners and decision-makers. This approach not only ensures the robustness of hydrometeorologic studies but also contributes to more informed and confident decision-making processes in the face of complex environmental challenges. This work showcases the potential of machine learning in advancing the field of hydroclimate, providing a valuable framework for future studies and applications. The integration of machine learning techniques not only enhances data quality but also establishes a pathway for more comprehensive and reliable hydrometeorologic analyses.

Kristin TePas[1], **Nate Drag**[2] and Ashley Eaton[3], [1]University of Illinois, IL-IN Sea Grant, [2]New York Sea Grant, [3]University of Vermont, Lake Champlain Sea Grant. **Overview of Social Science Research on the Shipboard Science Workshop Impacts.**

Since 2006, over 200 educators from across the Great Lakes have participated in the annual Shipboard Science Workshop aboard the EPA's R/V *Lake Guardian*. This one-of-a-kind opportunity for educators to gain an intimate understanding of the Great Lakes is organized by Sea Grant's Center for Great Lakes Literacy and most recently occurred on Lake Ontario in the summer of 2023. This presentation will provide an overview of recent and ongoing social science research on the impact of this weeklong workshop on educators, looking at changes in their Great Lakes literacy, teaching efficacy, and sense of place. Additionally, the presentation will provide an overview of a social network analysis exploring the extent of the ongoing relationships among the participants to better understand the strength of the community of practice. Lastly, presenters will highlight characteristics of the workshop that have contributed to its success.

Ethan J. Theuerkauf, Hannah C. Griffith, CarLee S. Stimpfel and Nathaniel H. Penrod, Department of Geography, Environment, and Spatial Sciences, Michigan State University. **Timing and processes associated with beach recovery following recent high Lake Huron water level.**

Beach recovery following periods of above-average Great Lakes water level is a function of sediment availability within a narrow portion of the nearshore. Although beach width may increase as inundated portions of the nearshore are re-exposed as lake level falls, beach recovery requires that accretionary waves transport eroded sand back onto the beach. Recovery likelihood can be predicted by identifying the active zones of coastal sediment transport under varying wave and water level conditions. In general, when sand deposits are in the shallow nearshore, the probability that

accretionary waves can push that material back onto the beach increases. While this conceptual framework explains the processes driving recovery and can identify whether recovery is possible for a given beach, it does not predict the timing of recovery, which can be slower than anticipated even when abundant sand is located near the shoreline. Recent results from a field study at Port Crescent State Park along Lake Huron in Michigan's Thumb Region indicate that even when abundant sand supply occurs in a shallow and gently sloping nearshore, beach recovery following high lake level is a slow process that is frequently interrupted by changing wind and wave directions and rivermouth bar dynamics. The net impact of these hydrodynamic and geomorphic processes is to slow beach recovery, potentially increasing the site's vulnerability to storm events and future lake level rise.

Wendy Tian, Colin Wood and Caleb Karmelich, CSIRO. **Advancing hyper-crosslinked materials with high efficiency and reusability for oil spill response.**

A hyper-crosslinked polymer-coated sponge (HPCS) was developed and showed its high efficiency for oil/water separation and recovery under challenging conditions. A commercial melamine formaldehyde sponge was coated with an optimised superhydrophobic/superoleophilic hyper-crosslinked polymer and applied to the removal of crude oil from oil-in-water emulsions for the improvement of oil spill clean-up processes. The high surface area, porosity, hydrophobicity, and selectivity of oil over water made the HPCS an ideal sorbent for efficient oil/water separation. The system was able to strip crude oil from water emulsions of 1000 ppm to a negligible level of 2 ppm oil with minimal amounts of the HPCS material. More importantly, the HPCS material could be reused via a simple mechanical compression process, and the uptake capacity was retained over ten cycles.

Sydney Todd and Josef Ackerman, University of Guelph. **The effect of total nitrogen flux on nutrient cycling in a freshwater mussel, *Lampsilis siliquoidea.***

Freshwater unionid mussels, deemed ecosystem engineers, modify the environment through feeding and burrowing. In addition to their improvement of water clarity, mussels' role in nutrient cycling has been well-documented under static conditions. They clear particulate nitrogen, which is returned to the ecosystem as dissolved ammoniacal nitrogen or loosely-bound biodeposits, but this process has not been examined under different water flow nor ambient nitrogen concentrations - collectively nitrogen flux (i.e., flux (J) = concentration (C) × velocity (U)). Consequently, the clearance, excretion, and biodeposition rates of adult male *Lampsilis siliquoidea* mussels from the Thames River, ON were examined under 16 treatments, i.e., combinations of water velocities (0 cm/s, 5 cm/s, 15 cm/s, 25 cm/s) and TN concentrations (10 µg/L, 100 µg/L, 1000 µg/L, 10000 µg/L). Results indicate that clearance rates increase with increased TN until ~10000 µg/L TN when they appear to saturate. Clearance rates were higher at the 1000 ug/L TN level for all velocities, with this difference being significant at both 5 cm/s and 15 cm/s. Results indicate that TN flux influences mussel clearance rate, and thus their ability to clear the water column beyond a TN threshold. Analysis of biodeposition and excretion rates is underway and will be reported. This research is crucial for understanding mussel nutrient cycling amid changes to baseflow and nutrient loads and allows insight into how these processes may shift with climate-induced changes.

Péter Torma[1], Zsombor Reska[2], Judit Barbara Nagy[1], András Rehák[1] and Géza Hajnal[1], [1]National Laboratory for Water Science and Water Security, Department of Hydraulic and Water Resources Engineering, Faculty of Civil Engineering, Budapest University of Technology and Economics, Budapest, Hungary, [2]Department of Hydraulic and Water Resources Engineering, Faculty of Civil

Engineering, Budapest University of Technology and Economics, Budapest, Hungary. **Analyzing the turbulent air-water fluxes and the energy balance of a geothermal lake.**

Lake Hévíz is Europe's largest geothermal lake, with a surface area of 4.4 ha. It is a peat lake, supplied by nearly 40 °C warm spring water. A constantly recurring question is the emittance and absorption of atmospheric greenhouse gases, such as water vapor and CO_2. Considering water vapor, water temperature plays an important role, which is high throughout the year as the lake's surface temperature is above 20 °C even in the winter. As a result, intensive evaporation may occur throughout the year, compared to natural lakes in the same climate. Regarding CO_2, the peaty sediment plays a crucial role, as its emission can be significant. Furthermore, due to the warm incoming flow at a depth of 40 meters, highly varying stratification and mixing conditions develop. We performed several week-long measurements to explore the energy and water balance of the lake. Besides measuring the regulated outflow, the dominant energy balance components have been recorded, including incoming and outgoing short- and long-wave radiations, water temperature, and turbulent heat fluxes. The latter ones and CO_2 fluxes were directly measured by the eddy-covariance technique. In this study, first, we determine the energy and water balance of the lake and the possible causes of their closure errors. Second, we reveal the characteristics of turbulent heat and CO_2 fluxes and their main driving forces for this unique warm water lake.

Sebestyén Török and Péter Torma, Budapest University of Technology and Economics. **Predicting stratification in a shallow lake in the light of changing climate and water levels.**

Lake Balaton is a shallow polymictic lake with weak and typically diurnal stratification. Model simulations of the last forty years showed that climate change and water level regulations significantly affect the lake's thermal structure. When considering their combined synergistic effect, higher water levels greatly amplify the impact of climate change, substantially intensifying stratification and causing longer stratified periods that can remain for several days. In this study, we examine the change in Lake Balaton's stratification across various climate scenarios over the coming decades. We quantify the possible changes in the intensity and duration of stratification due to climate change and investigate how they can be influenced by water level regulation. The calibrated and validated 1D General Ocean Turbulence Model (GOTM) is applied for modeling. As stratification has a diurnal cycle, a sub-daily resolution with at least three hours is necessary to describe the lake's thermal structure. Since climate models provide reliable estimates on a daily resolution at most, downscaling of the meteorological parameters, including wind speed, solar radiation, and air temperature, is required. Moreover, as GOTM calculates latent heat fluxes, the modeling also provides an opportunity to examine the lake's future evaporation, which is the primary loss term in the lake's water balance.

Mathilde Tremblay, **Hope Dettweiler**, **Mitchell Dalton** and Tim P. Duval, Department of Geography, Geomatics and Environment, University of Toronto Mississauga. **Stormwater Management Ponds Under Ice: Impacts of Winter Dynamics on Urban Ponds.**

Shallow urban pond dynamics remain a mystery in the current limnological literature. Previously, water quality parameters were assumed to be homogenous throughout shallow, less than 2 m deep, urban ponds. Recent research suggests urban ponds experience chemical and thermal stratification for prolonged periods of time in the summer; the duration of inverse thermal stratification during winter months evades the literature. We investigate these dynamics in Mississauga, Ontario by taking water quality parameters at four sampling locations in a stormwater management pond (SWMP) and a nearby natural pond as a control. At each location, water quality parameters consisting of temperature, dissolved oxygen, percent saturation, pH, electrical

conductivity, and pressure are taken at three depths (surface, middle, and bottom). Our results add to urban pond research by demonstrating strong inverse thermal stratification is possible despite their shallow nature. During the month of January, one of our SWMP's sampling locations experienced a temperature difference from top to bottom of -5.43℃ with a calculated thermocline of -4.94℃/m despite a water depth of only 1.3 m. The same sampling location experienced a difference of 4243 μS/cm of electrical conductivity from the top to the bottom of the water column demonstrating strong chemical stratification is possible even with the presence of an outflow. These findings are relevant as hostile conditions in SWMPs have the potential to negatively impact downstream aquatic ecosystems.

Cary Troy and Hazem Abdelhady, Purdue University. **The Great Lakes Shoreline Model - Overview and Applications.**

Recent water level increases in the Great Lakes caused widespread shoreline changes, and highlighted the need for shoreline models that can capture the influence of such fluctuations on morphodynamic changes. In this work, we highlight the development and applications of a newly developed reduced-complexity shoreline model, the "Great Lakes Shoreline Model", which was developed specifically to simulate water level effects on shoreline changes in the Great Lakes. The model is based on the concept of "water level disequilibrium", for which wave forcing is modulated by the magnitude of water level changes relative to recent, "equilibrium" conditions as defined with a suitable timescale. This modulation is analogous to the wave disequilibrium formulation used in other popular ocean shoreline models, where changes from equilibrium forcing lead to enhanced shoreline changes. Calibrated with high-resolution multi-spectral satellite imagery, the Great Lakes Shoreline Model shows promise in accurately simulating changing shorelines for several test locations in Lake Michigan, in response to a broad spectrum of water level fluctuations ranging from storms to interannual variations. Idealized test cases highlight the fundamental mechanism driving Great Lakes shoreline responses to large water level fluctuations, for which there is no oceanic analog. Ongoing work seeks to generalize model parameters in terms of beach parameters and other defining characteristics.

Kate Truitt, Amanda Grimm and Nicole Zacharda, Great Lakes Commission. **Web GIS frameworks for data collaboration in the Great Lakes Region.**

As the interstate compact agency for the Great Lakes Basin, the Great Lakes Commission (GLC) is in a unique position to foster greater communication and collaboration among many of the agencies and organizations responsible for the collection, management and delivery of Great Lakes data and information. Some of the issues that the GLC is currently working to address include the reduction of nutrient loads that contribute to harmful algal blooms (HABs), stopping the spread of aquatic invasive species (AIS), and monitoring Great Lakes drinking water. The GLC has developed interactive web GIS tools for each of these issue areas; this presentation will introduce work by GLC and partners including a web experience promoting research collaboration on HABs, app-based mobile data collection for mapping AIS, and an open data portal. We also highlight some of the challenges encountered in designing and developing tools for diverse purposes and user groups. Accessible, web-based tools that promote the collection and sharing of data and information in real time provide the foundation for better understanding and protecting our Great Lakes and ensuring a healthy and sustainable future for the region through collaborative management and governance.

Justin Trumpickas[1] and Erin S. Dunlop[1,2], [1]Ontario Ministry of Natural Resources and Forestry, [2]Trent University. **Seasonal spatial distribution of lake whitefish in Lake Simcoe, Ontario.**

Lake whitefish (*Coregonus clupeaformis*) are a species of management concern in Lake Simcoe. Stressors on this population include fishery harvest and low hypolimnetic dissolved oxygen levels in the summer. The population is composed of few naturally-reproduced year classes and is supplemented by rehabilitative stocking. To understand the habitat usage of lake whitefish and the extent of habitat overlap with lake trout (*Salvelinus namaycush*), an acoustic telemetry array was deployed in Lake Simcoe starting in November 2020 and growing to 44 receivers by October 2022. Lake whitefish were acoustically tagged in the fall of 2020 (n=12) and 2022 (n=51). 58% of 2020 tagged whitefish and 59% of 2022 tagged whitefish were still moving within the array by June 2023. Home ranges of these surviving fish were estimated using detection data up to June 2023. Home range sizes were compared across seasons, between stocked and natural origin fish, and between males and females. In addition, the overlap in seasonal home range with acoustically tagged lake trout was used to compare habitats of these species. Characterizing lake whitefish spatial distribution increases our understanding of factors, such as habitat quality, impeding this population's recovery in Lake Simcoe.

Fani Tsaroucha, Great Lakes Institute for Environmental Research. **Making way for boundary spanners and actionable science in Great Lakes restoration.**

Ecosystem Approach Project (ECAP, HHL) is an initiative that seeks answers on how to advance the operationalization of an ecosystem approach in the Great Lakes basin. Through multi-stakeholder engagement, the ECAP convened workshops for diverse groups of actors in restoration to share and co-produce knowledge, generate feedback, and co-innovate solutions leading to more effective use of ecosystem approach. Over a course of 18 months, an international conference with synthesis workgroups and manuscripts, 15 participatory workshops, and a stakeholder feedback survey were employed to identify ways and means to make greater use of an ecosystem approach. Acting as a knowledge broker, the ECAP team engaged a broad range of stakeholders across the region in strengthening science-policy-management linkages. Stakeholder feedback was obtained through workshops and a feedback survey, and synthesized into a report, including practical recommendations that were submitted to the Great Lakes Program Office, Environment and Climate Change Canada. This boundary spanning research is an extension of HHL's commitment to actionable science and to strengthening relationships between science providers and users under an umbrella of projects such as the Farmers Advisory Board, the Indigenous Knowledge Circle, and the Ojibway National Urban Park.

Nicole Turner[1], Christine Boston[1], Robert Bajno[1], Ian Smith[2], Matthew Yates[2], Hugh MacIsaac[2] and Jon Midwood[1], [1]fisheries and oceans canada, [2]University of Windsor. **Detecting goldfish (Carassius auratus) and native fishes in urban ponds using eDNA and conventional fish sampling.**

Aquatic invasive species pose a significant threat to native ecosystems, particularly in areas of increased pressure from anthropogenic stressors. The live organism trade has been identified as a high-risk pathway for the introduction and establishment of non-native species, particularly within densely populated urban landscapes. One notably high-risk species, goldfish (*Carassius auratus*), was identified as being prone to release and establishment in freshwater systems including stormwater management ponds (SWMPs), which are often hydrologically connected to natural waterways. We paired environmental DNA (eDNA) technologies (metabarcoding and targeted qPCR) with conventional fisheries sampling (electrofishing or seine netting) to survey for the presence of

Goldfish in SWMPs throughout Hamilton, Ontario. Between 2021 and 2022, 32 ponds were sampled for both eDNA and fish. In addition, a subset of 10 ponds were selected for dewatering to further validate the results of eDNA and fish sampling. In total, 22 species of native and non-native fishes were detected including the invasive goldfish in 12 out of 32 ponds. Preliminary metabarcoding and qPCR results indicate a strong positive relationship with fish sampling techniques. This dataset will be instrumental in the development and implementation of early AIS detection tools, such as eDNA, particularly in SWMPs across urban landscapes where invasive species pose an elevated risk of spreading to natural systems.

Michael Twiss[1], Ashley Moerke[2] and Jeffrey Ridal[3], [1]Faculty of Science, Algoma University, [2]College of Great Lakes Ecology and Education, Lake Superior State University, [3]River Institute.
Expanding the REASON project across the Great Lakes Connecting Waters: St. Lawrence & St Marys Rivers.

As the sole outflow of Lake Superior and a nexus of the upper Great Lakes, the St. Marys River is an ecologically and economically important connecting water. Water quality monitoring has been historically limited in this region and year-round, continuous water quality data collection is needed. We are expanding the River Environment And Sensor Observation Network (REASON) to a node on the St. Marys River at the outflow of Lake Superior. The initial installation is at the outflow of a canal traversing the city of Sault Sainte Marie, Michigan (power station operated by Cloverland Electric). This location will measure shoreline water quality impacts along the Michigan shore, with local urban impacts. The sensors (Turner Designs C6P) used are fluorimetric and measure chlorophyll-a, phycocyanin, oil, turbidity, and CDOM) as well as temperature and specific conductivity sensors. Further installations are planned for dams that are situated in the main channel that reflects offshore Lake Superior water, and shoreline river flow along the heavily industrialized Ontario shoreline. Collectively, these sensors and an academic-government agency-private industry partnership will provide high-resolution water quality data that will help inform water quality regulation, climate change strategies, land use development, and will further enhance our understanding of seasonal and annual biogeochemical dynamics in the upper Great Lakes and help us meet our responsibilities towards maintaining healthy coastal ecosystems.

Marguerite Xenopoulos[1] and **Michael Twiss**[2], [1]Department of Biology, Trent University, [2]Faculty of Science, Algoma University. **Status of winter science in the Great Lakes: defining future needs.**

Winter is an overlooked season across the Great Lakes basin, yet we often base our management decisions on models derived from ice-free observations. Observations during winter are particularly challenging: they require specialized equipment, highly qualified personnel, and coordinated approaches among science priority and research coordination experts. The Great Lakes are especially vulnerable to ice cover loss and are warming at alarmingly fast rates. As members of the Science Advisory Board of the International Joint Commission, we are currently leading a working group to help prioritize science needs and coordination of efforts amongst agencies and scientists to meet knowledge gaps as they relate to winter science in the Great Lakes. A preliminary report will be made on results of two virtual workshops (1) to establish winter science priorities, and (2) to determine current capacities for winter science across the region. The third in-person workshop determined the research coordination required to meet the needs identified in the first two workshops. Preliminary results identify the need for specialized equipment and personnel and long-term data in winter and adjacent seasons to understand the influence of climate change on chemical, physical, and biological processes, a better prioritization of science needs, and

coordination of efforts amongst agencies to meet these data needs and gaps. Preliminary recommendations to satisfy science needs and meet capacity for winter science in the Great Lakes will be presented.

Alana Tyner and Andrea Kirkwood, Ontario Tech University. **Using bioassessment as a tool to evaluate the effects of different aquatic vegetation control methods in the Kawartha Lakes.**

The Kawartha Lakes region is part of Trent-Severn Waterway National Historic Site of Canada system that links Lake Huron and Lake Ontario. Two lakes in this region (Canal and Scugog) experience excessive aquatic vegetation growth due to several factors including their shallow depth, high nutrients, and the historical establishment of weedy invasive species. Additionally, increased shoreline development has caused significant alterations to the shoreline which may also be exacerbating water quality issues. As part of an ecosystem-scale collaborative field study known as Trent-Severn Aquatic Plant Experimental Removal (TAPER), which employed a Before-After-Control-Impact (BACI) design, we applied a bioassessment approach using standardized colonization substrates to compare macroinvertebrate communities across replicate sites of four treatment types: Control, Aquatic Thruster, Weedsickle, and Lake Rake. Our main research objective was to compare differences in macroinvertebrate abundance and community composition across treatments to ascertain if the amount and type of vegetation removed affected community structure. The strengths and limitations of this approach will be discussed, in addition to a presentation of our overall bioassessment findings, which are currently being processed and analysed.

U

Melissa Baird[1], Valoree Gagnon[1], Judith Perlinger[1], **Noel Urban**[1], Evelyn Ravindran[2], Larissa Juip[1] and Cassandra Reed-VanDam[1], [1]Michigan Technological University, [2]Natural Resources Department, Keweenaw Bay Indian Community. **Convergence Research and Lessons from Geese.**

"Convergence research" is one step in the evolution of our conception of research from a unidirectional action by an individual on an object or system to multi-directional interactions between researchers of multiple disciplines or "trainings," the communities of the researchers, and the communities within which the research is performed. Defined variously by different groups, convergence research typically addresses challenges or a compelling problem, multiple disciplines and/or viewpoints, integration of viewpoints, and production of knowledge that may lead to a problem solution. This talk illustrates practices and challenges of convergence research conducted with/by/as the Keweenaw Bay Indian Community (KBIC), an Ojibwe Tribal Nation who hunts, fishes, and gathers in western Gichigami (Lake Superior) and its watershed, in conjunction with a team of researchers from Michigan Technological University and from the Great Lakes Indian Fish and Wildlife Commission (GLIFWC). The compelling problem prioritized by the KBIC was the contamination of natural resources by colonialist activities. This talk will focus on a) the impact on this project of the intersection of multiple time arcs; b) the frictions and tensions inherent in convergence work and their role in shaping the project outcome; and c) collisions, bridging, integration, and other tools and approaches needed to identify and apply solutions.

V

Iradukunda Valentine, Africa Center of Excellence for Water Management. **Climate Change and Land Use Impacts on Hydrology of Ethiopia Rift Valley River Basin.**

Climate and land use change have significant impacts on water resources, biodiversity. This study focuses on the evaluation of the separate and combined effects of both LULC and climate change on hydrology using SWAT, CMIP6 model and CMhyd tool. Historical LULC was classified from Landsat images, the future LULC prediction was generated using Cellular Automata-Markov Chain model. The hydrological processes of the basin was estimated by incorporating three scenarios in future period including LULC change only and climate only as well as their combination, for 2020s, 2050s and 2080s. The results of predicting LULC changes using CA Markov chain model indicates that the agricultural land area increased by 27.5%, the built up area increased by 0.8%, the wetland increased by 1.6%, and natural vegetation, water bodies, and grasslands increased by 24.5%, 0.5%, and 2.1%, respectively by 2020, 2050, and 2080 years. Climate projection results shows rising in both Tmax to 2.45 ◦C and Tmin to 2.42 ◦C temperatures, while precipitation increased by 12% in the basin. Evapotranspiration increased to 0.54%, 49.6%, and 35.5% in three scenarios respectively by the end of the 21century in SSP8.5 compared to the baseline period. Stream flows of basin were predicted to account for 23.1%, 32.5%, and 44.4% for LULC, climate, and incorporated climate and LULC change scenarios respectively. Effects of climate change are higher than the combined effects of changes in climate and LULC.

Reza Valipour[1], David Depew[1], Chris Dallimor[2], Matt Hipsey[3], Megan McCusker[1] and Yerubandi R Rao[1], [1]Environment and Climate Change Canada, [2]HydroNumerics, [3]The University of Western Australia. **High-resolution modeling to simulate mussels' nutrient recycling and Cladophora growth in Lake Erie.**

We develop two different high-resolution three-dimensional hydrodynamic and water quality models for Lake Erie: AEM3D with a structured mesh and Tuflow-AE2 with an unstructured mesh. These models can resolve predominant physical and biochemical nearshore and offshore processes to study nutrient dynamics, with a particular emphasis on the northern nearshore region of Lake Erie's eastern basin. The water quality modules of both models include coupled mussels and *Cladophora* Growth Model (CGM) to assess the role of nutrient re-cycling by mussels and predict *Cladophora* growth in eastern Lake Erie. The models are validated using extensive nearshore hydrodynamic and water quality observations such as temperature and velocity profiles, total and soluble phosphorous, *Cladophora* biomass and tissue phosphorus measurements. Both models are used to evaluate the response of nearshore phosphorus concentrations and *Cladophora* growth due to changes in external phosphorus loading and the results are compared with a previously developed high-resolution three-dimensional ELCOM-CAEDYM model with an offline CGM module without mussels.

Serghei Bocaniov[1], Donald Scavia[2] and **Philippe Van Cappellen**[1], [1]University of Waterloo, Waterloo, Ontario, [2]University of Michigan, Ann Arbor, Michigan. **A revised phosphorus mass balance model for Lake Erie and applications to eutrophication management.**

Reducing total phosphorus (TP) loading to Lake Erie remains a key management tool to control eutrophication and associated ecological impacts including hypoxia, cyanobacterial blooms, and outbreaks of nuisance green algae. However, since the late 1990s, the coupling of the lake's ecological responses to external TP loading has become more tenuous suggesting a growing role of

other drivers of Lake Erie's eutrophication symptoms. To shed light on this issue, we constructed a long-term (2003-2016) average TP budget for both the whole lake and the individual basins and connecting channels. The TP budget implied the existence of significant, but yet uncategorized, in-lake TP sources that, together, amount to about one third of the total TP load to the water column, or about half the size of the external TP loading from the watershed. The mean water and TP residence times derived from the TP budget were used to derive TP load-response relationships and response matrices to predict steady state lake TP concentrations as a function of variable external TP inputs. The relationships were then extended to predict the following water quality and ecosystem indicators: Chlorophyll-a, water transparency, primary production, fish production and standing biomass. These relationships and matrices provide a simple but robust framework to gauge the potential long-term impacts of TP reduction interventions on Lake Erie's TP concentrations and associated environmental indicators.

Amy Van Zanen and Sara Hughes, University of Michigan School for Environment and Sustainability. **Drivers and barriers to using hydroclimate data and models in Great Lakes coastal risk management decisions.**

Advances in hydroclimate modeling provide an opportunity for improved decision-support in Great Lakes coastal areas. Specifically, water-level forecasts based on these models may inform and improve local decision making and coastal risk mitigation. While research on climate forecast use has shown that increases in the availability of information does not consistently lead to improved climate adaptation decisions or outcomes based on forecasts, this work has not yet examined forecast use and risk management decision contexts among coastal managers in the Laurentian Great Lakes. We will present findings from semi-structured interviews in several coastal counties on the decisions coastal managers can and do make for mitigating water-level-related risks and the role hydroclimate data (and lake level forecasts in particular) plays in supporting and informing these decisions.

Dorthea Vander Bilt[1], Laura Bourgeau-Chavez[1], Colin Brooks[1], Chris Cook[1], Amanda Grimm[2], Phylis Higman[3] and Stephanie Hoyle[4], [1]Michigan Tech Research Institute, [2]Great Lakes Commission, [3]Michigan Natural Features Inventory, [4]Saginaw Bay CISMA. **Using Multitemporal Remote Sensing to Monitor Treatment and Restoration of Phragmites infested Great Lakes Wetlands.**

Invasive species are notorious for their ability to rapidly spread and out compete native species. Great Lakes coastal and riverine wetlands have been severely impacted by aggressive non-native species, such as *Phragmites australis* (common reed), resulting in enormous loss of critical habitat for native species and severe impacts for economic and recreational pursuits. For more than a decade, MTRI researchers have partnered with state and federal governments, land managers and local conservation entities, and property owners to develop a framework for the long-term control of *Phragmites australis*. Remote sensing data with high spatial and temporal resolution can expand field-data collection efforts to track invasive species extents, quantify treatment efficacy, and identify additional invasions to a landscape scale. In Saginaw Bay, multispectral imagery from DigitalGlobe WorldView (2.5m), PlanetLabs Planetscope (3m), and uncrewed aerial vehicles (UAVs, <=15cm) have been used to monitor the treatment of more than 6,000 acres of coastal and riverine wetland habitat from the >0.8 km deep *Phragmites* wall of invasion since 2016. Results show high treatment success, with a reduction of 73% *Phragmites* from 2016-18 in the initial 739 acres restoration area and >93% in the reduction of *Phragmites* from 2020-22 in the 1,857 acres restoration region. Additionally, a return of desirable native vegetation and wildlife has been observed post-treatment in areas

previously dominated with Phragmites in Saginaw Bay indicating wetland resilience after *Phragmites* removal.

Andrea Vander Woude, NOAA Great Lakes Environmental Research Laboratory. **New Developments on the National Oceanic and Atmospheric Administration Great Lakes CoastWatch Satellite Data Repository.**

CoastWatch translates satellite data to regional applications on a global scale. In the Great Lakes, satellite data products are widely used by stakeholders for decision-making processes that indicate ecosystem health, determine fishing practices, ice dynamics, vessel planning, and initialize hydrodynamic models. The demand for synoptic satellite data within our changing Great Lakes ecosystem has required the development of new CoastWatch products. Some of the additions to the CoastWatch satellite data repository include but are not limited to an update to the long-standing Great Lakes Surface Environmental Analysis (GLSEA) gap-free lake surface temperatures, statistical interpretations of trends, and new algorithms for water clarity. The updates to the satellite products include moving the website into the next generation of data accessibility requirements in a cloud environment and allowing the flexibility to continue to add new applications and products in the future. New developments for CoastWatch applications highlight the need for long-term trends in water quality parameters and a greater understanding of ecosystem health and climate factors.

Chris Vandergoot[1], Lisa O'Connor[2], Scott Schlueter[3] and Matthew Faust[4], [1]Michigan State University, [2]Fisheries and Oceans Canada, [3]US Fish and Wildlife Service, [4]Ohio Department of Natural Resources. **Benefits, Challenges and Opportunities of Conducting Multi-Jurisdictional Fish Movement Research on the Laurentian Great Lakes.**

The management of ecologically and economically important fish populations on the Laurentian Great Lakes is complicated by the fact that these species regularly exhibit cross-lake, multi-jurisdictional movements. Prior to the establishment of Great Lakes Fishery Commission in 1955 to control the spread of invasive Sea Lamprey, cohesive and collaborative management of this important fishery resource was non-existent due to the lack of coordinated management efforts. Working under the auspices of the GLFC, a basin-wide research collaborative focused on understanding the complex movements of Great Lakes fishes using acoustic telemetry was initiated in 2010. The Great Lakes Acoustic Telemetry Observation System (GLATOS) provides researchers with the ability to track and monitor the movement of fish despite crossing inter-jurisdictional borders. Researchers work cooperatively with Canadian and United States of Ameria Border Services for maintaining the arrays on both sides of the border. This presentation will focus on describing the benefits, challenges, and opportunities of conducting large-scale fish movement research across multi-national jurisdictions.

Henry A. Vanderploeg[1], Donald Scavia[2] and Gustav-Adolph Paffenhöfer[3], [1]NOAA Great Lakes Environmental Research Laboratory, [2]School for Environment and Sustainability, University of Michigan, [3]Skidaway Institute of Oceanography. **Grazing and predator-prey experiments that have changed our understanding Great Lakes food webs.**

Zooplankton and non-indigenous species research at GLERL has been a major driver of important concepts for understating food web dynamics of the Great Lakes and other systems. We will revisit the early evolution of GLERL and colleagues work that led to development of important measurable descriptions of food selection (selectivity) and feeding rate, and development of new conceptual frameworks and models for understanding predator and prey interactions. An important part of the research was complementary use of direct observations of feeding mechanisms using

high-speed microscopy and videography to identify components of predation, giving insights that could not be determined from traditional laboratory or field experiments. Specific examples drawn from research on zooplankton, Mysis, and nonindigenous species will be given to show the interplay between experimentation, concept development, models, and their implications for Great Lakes food webs. GLERL experiments advanced understanding of the role of grazers on plankton succession and harmful algal blooms, and interactions of planktivores with zooplankton. Experimental results when coupled with life-cycle strategies and detailed information on spatial distributions of consumers and prey biomass are shown to be important for demonstrating impact. Some of the lessons have been forgotten, and modelers of food web and fisheries response to multiple stressors would benefit from treating predator and prey feeding and escape mechanisms as important traits in addition to predator and prey characteristics derived from traditional laboratory or field studies.

Edward Verhamme, Ken Gibbons, Greg Cutrell and Zach Gordon, LimnoTech. **Small Tech = Big Impact on Great Lakes Science.**

Although autonomous and self navigating water monitoring technology gets much of the media attention, it comes with a significant purchase/maintenance cost and significant retraining of technicians. Simple advancements in lower cost monitoring offer to revolutionize almost any scientific study and allow for large scale deployments to match the scale of Great Lakes phenomena. This presentation will review case studies from Lake Erie that look at the use of modern batch manufacturing of wave, wind, water level, and water quality sensors across a large section of Western and Central Lake Erie. The massive amounts of data that can be generated by this approach, including an O&M plan to keep these data streams online.

Emily Verkuil, Yolanda Hedberg, Christopher Power and Melanie Blackburn, University of Western Ontario. **Is there an alternative? Ice-Melting Capacity and Environmental Impact of De-icers.**

In Canada, since the 1940's, sodium chloride (NaCl) has been used as a de-icer on roads and paved surfaces to maintain safe, passible transportation facilities. Canada applies over 6 million tons annually, leading to a range of social, economic, and environmental issues, including corrosion to infrastructure and vehicles, damage to vegetation, salinization of freshwater resources, and the flushing of contaminants from soil. These problems are expected to grow with urbanization in Canada. Therefore, significant interest exists in alternative de-icing salts that decrease environmental impact but maintain safe transportation facilities. Current alternatives include calcium chloride, potassium chloride, magnesium chloride, calcium magnesium acetate, and sodium acetate, but are used sparingly due to their high relative cost. The objective of this study is to perform a multi-disciplinary investigation using laboratory and field tests to compare these de-icers, along with two proprietary de-icers developed by the partner organization in this study, Cypher Environmental, for their ice-melting performance and environmental impact. Ice-melting and penetration were performed in accordance with the Strategic Highway Research Program (SHRP) test methods H205.1 and H205.2, and in field tests to obtain real-world results. Environmental impact was assessed using pore water samples from field tests and in laboratory batch testing to assess metal mobilization from exposure to various de-icers. Overall, this research will help obtain a better consensus and optimization for the diverse performance, benefits, and limitations of alternative de-icing products.

Natalija Vojno, Our Future First. **Casting Ripples: The potential of watershed based civic assemblies.**

A place-based circle dialogue process is explored as a social technology for civic sense-making. This localised approach to watershed-based governance was prototyped as a form of civic assembly in the Etobicoke Creek and Humber River watershed. As an organizing tool, circle processes are one of the oldest models humanity has used to build social-cohesion. The representative and community-building potential of the circle process is explored in relation to a shared nature-based identity. Acknowledging that "the practice of foresight is not neutral" but draws upon positionality and cultural values, visioning activities applied a decolonial approach that interrogates patterns of power and considers perspective alongside possible, preferable, plausible and probable futures (Krishnan, 2022). This ontological shift opens up a pluriversal way of knowing and being across time that enables a more diverse array of viable policy responses (Vojno, 2022). The natural entanglements of climate adaptation and resilience are experienced through watershed based planning. Using the method of circle processes, inter-generational groups of residents living within sub-watersheds were gathered in dialogue. The participatory dimension of social infrastructure enables the agency of all to cooperatively realize multiple co-benefits over time (Engle et al, 2022). While gathering in a circle, values and understandings of the system are surfaced and made known to the whole.

W

John Walakira[1], Catherine Agoe[1], Ezra Tumukunde[2], Kunda Ndashe[3], Carles Castells[4], Labrie Lauke[5] and Adrian Astier[6], [1]National Agricultural Research Organisation, [2]Ministry of Agriculture, Animal Industry and Fisheries, [3]University of Zambia, [4]Ictiovet, [5]IctyoDev, [6]Virbac. **Emerging Pathogens Isolated from Farmed Tilapia: Lake Victoria, Uganda.**

Tilapia production from aquaculture is growing fast in Uganda to meet the increasing demand for fish. Farm yields and profits are increasingly reduced by periodic disease outbreaks in land and water-based systems. High mortalities experienced within hatcheries and cage systems with infected fish presenting signs of lethargy, exophthalmia, granulomatous spleen, fin rot, ulcerations and haemorrhages. Histopathological reports showed gill hyperplasia with epitheliocystis, and granulomatous head-kidney, spleen, liver with melanomacrophages. However, asymptomatic fish samples showed recovery stages of populations as exhibited in granulomas spleen and kidney. Molecular identification revealed unique strains of Aeromonas veronii, A. hydrophila of Edwardsiella ictaluri, E.tarda, E. anguillarum, Francisella philomiragia, F. noatunensis and F. tularensis from infected farmed tilapia in Uganda. These were resistant to Ampicillin and Amoxicillin, erythromycin and sulfamethoxazole trimethoprim, respectively. Identification of co-occurrence of these emerging pathogens presents strategies to reduce further economic losses in the tilapia industry.

Carol Waldmann Rosenbaum[1] and Elena Litchman[1, 2], [1]Michigan State University, [2]Carnegie Institution for Science. **Temperature traits in cyanobacterial populations from the Laurentian Great Lakes.**

Cyanobacterial harmful algal blooms (cHABs) are a major environmental problem that threatens water quality, ecosystem and human health, and coastal communities' livelihoods. The frequency and severity of cHABs have increased worldwide, including in the Laurentian Great Lakes (LGLs). Despite diverse environments across the LGLs, the same bloom-forming taxa are present in

all five lakes, suggesting that these cyanobacterial genera have adapted to a broad range of conditions. Although only a few genera compose most of the regional blooms, there is great inter- and intraspecific genetic and functional diversity within these genera, which may aid cyanobacterial adaptation to local conditions. We investigate how temperature traits such as temperature optima and width vary across and within cyanobacterial populations in the LGLs. We measured growth rates for 60 cyanobacterial strains isolated from Lakes Superior, Michigan, Huron, and Erie in 2022 and 2023. We found that Lake Superior strains have lower temperature optima and lower maximal growth rates. Additionally, Lake Superior's strains have larger cell sizes in comparison to Erie and Michigan strains. Our results contribute to evidence of great inter- and intraspecific functional diversity within and across cyanobacterial LGLs' populations and suggest that cyanobacterial strains in Lake Superior are likely limited by temperature. Further assessing nutrient and genetic traits would contribute to mechanistic explanations of community dynamics and helps us understand species abundance and succession across environmental gradients such as in the LGLs.

Jia Wang[1], Haoguo Hu[2], Ayumi Fujisaki-Manome[2] and David Cannon[2], [1]NOAA Great Lakes Environmental Research Laboratory, [2]University of Michigan, CIGLR. **GLERL's 50 Years of Great Lakes Ice Modeling and Prediction.**

From 2007 on to 2019 (12 years), GLERL continued to maintain and update the ice atlas for research and community service. Inspired by the legacy of Ray Assel's works, a new era of ice studies began in the following areas, including transition of research to application and forecasting (R2X): 1) Multi-variable, nonlinear regression, statistical models were developed to provide lake ice seasonal forecast, 2) Development of coupled Great Lakes Ice-circulation Model (GLIM) for 5-day lake ice forecast (first generation GLCFS), 3) Development of FVCOM_CICE to the Great Lakes for research and forecast for 5-day forecasts of ice-lake conditions (second generation GLCFS), 4) Development of fully coupled FVCOM_CICE+SWAVE model and measurement of ice, waves, and current using AWACs and SWIPs under the ice, 5) Hosted International Ice Symposium of IAHR in 2016 and International Workshop on Modeling the Ocean (IWMO) in 2022 to further promote Great Lakes ice studies, modeling and forecasting. From 2020 on, GLERL started to further develop Great Lakes Earth System Model (GLESM) by coupling FVCOM_CICE and low-to-high trophic level fisheries model, ATLANIS. Both models successfully conducted hindcast simulations from 1979-2021 in comparison with measurements. FVCOM_CICE now is capable to project Great Lakes ice-lake climate into 2100 under the 3 CMIP6 model forcing including GFDL CM4. The future ecosystems and fisheries climate is being projected by ATLANTIS.

Jia Wang[1], David Cannon[2] and Ayumi Fujisaki-Manome[2], [1]NOAA Great Lakes Environmental Research Laboratory, [2]University of Michigan, CIGLR. **Modeling two-way ice-wave interactions using GL-FVCOM_ice+wave model.**

A two-way fully coupled wave-ice model is being developed with the ability to resolve ice-induced attenuation of waves and ice breaking by waves. Wave and ice interactive dynamics in the Laurentian Great Lakes were simulated using the Finite-Volume Community Ocean Model (FVCOM) framework. Seven simple, flexible, and efficient parameterization schemes originating from the WAVEWATCH III® IC4 were used to quantify the wave energy loss during wave propagation under ice. Ice-induced reductions of wind energy input and wave energy dissipation via whitecapping and breaking were also implemented (i.e., blocking effect). A practical application of the model in February 2011 revealed that simulations could accurately reproduce the ice-attenuated waves when validated by wave observations from bottom-moored AWAC. However, the AWAC wave data showed quick responses between waves and ice, while the model with one-way coupling

was unable to simulate the quick response of ice melting. We are further developing a module in which wave-induced ice breakage reduces the floe size, thus increasing the lateral ice area and leading to enhanced lateral melting. This module is being applied to the five-lake model to complete the two-way coupling between ice and waves. Further validation using in-situ measurements is being conducted.

Zheng Wang[1], Chunjiang An[1], Kenneth Lee[2] and Qi Feng[1], [1]Concordia University, [2]Fisheries and Oceans Canada. **Application of nanobubbles for the cleanup of sand polluted by oil spills.**

Oil spills occurring in freshwater areas not only affect the freshwater ecosystem, but also seriously threaten the health of residents. There is a pressing need for fast, efficient, and environmentally friendly cleanup and recovery of oil spills in freshwater areas. Nanobubbles (NBs) have unique properties such as large specific surface area, high mass transfer efficiency, and strong oxidizing ability. They have been successfully employed in flotation, surface cleaning, irrigation, water treatment, soil remediation, drug delivery, and other fields. In this study, the removal of spilled oil from polluted sand in the presence of NBs was investigated, and the effects of temperature, pH, and external energy on the removal efficiency were considered. The results show that NBs can remove oil from sand through different ways. The removal efficiency varied under different conditions and thus an optimal condition can be applied for the most efficient removal. The use of NBs for oil spill cleanup offers an environmentally friendly and versatile solution that enhances ecosystem preservation, improves water quality, reduces health risks, and contributes to broader environmental sustainability.

Christopher S. Ward, Katelyn M. Brown, Ryan S. Wagner and George S. Bullerjahn, Bowling Green State. **Genomic insights into bloom-forming Nostocales taxa in the Lake Erie watershed.**

Recent changes in cyanobacterial bloom composition in waterbodies within the Lake Erie watershed have seen filamentous cyanobacteria associated with nitrogen fixation (e.g., *Anabaena-Dolichospermum-Aphanizomenon* (ADA), *Cylindrospermopsis/Raphidiopsis*) becoming major bloom-forming taxa. We explore two case studies in northern Ohio: (1) early summer *Aphanizomenon* blooms have occurred since 2019, following the recent disappearance of the perennial *Planktothrix* bloom in Sandusky Bay (Lake Erie); (2) late summer mixed algal blooms with moderate microcystin and saxitoxin concentrations in small lake. From bloom events, we have been obtained cyanobacterial isolates and undertaken whole genomic sequencing to gain greater understandings into the ecophysiologies, metabolisms, and toxin production potentials of the cyanobacterial taxa.

Jamie Ward, Cooperative Institute for Great Lakes Research. **Role of Extratropical Cyclones on Great Lakes Water Supply.**

Synoptic (i.e., large-scale) weather activity can impact Great Lakes water supply via changes in over-lake evaporation, over-lake precipitation, and basin-wide runoff (collectively referred to as net basin supply, NBS). Extratropical cyclones (ETCs) are one type of these synoptic systems that contribute to water supply variability via storm-induced atmospheric moisture transport and temperature changes. Given that water level fluctuations impact goods transport, hydropower generation, and ecological preservation efforts, it is important to how ETCs affect regional water supply. In this study, we analyze historical ETCs and their impact on NBS and each of its parameters using ERA5 and CFSR reanalysis data. We detect 6110 (3571) ETCs that enter the Great Lakes Region for ERA5 (CFSR) over all months in 1950-2019 (1979-2019). We track storm area influence for each ETC and calculate cumulative over-lake precipitation, evaporation, and runoff

change between 1 day before (2 days after) it enters (exits) the Great Lakes Region. Regardless of season or NBS parameter, Kruskal-Wallis testing indicates significantly different ETC-induced water supply changes between lakes. However, we find between-lake NBS variability is greater during the winter and spring. These results will inform efforts like the Bipartisan Infrastructure Law: Subseasonal to Annual (BIL-SA) project that seek to incorporate hydroclimate into future Great Lakes water level forecasting efforts.

Les Warren[1], Peter Euclide[1,2] and Tomas Höök[1,2], [1]Department of Forestry and Natural Resources, Purdue University, [2]Illinois-Indiana Sea Grant. **Genetic evidence of panmixia amongst Lake Michigan alewife, Alosa pseduoharengus.**

In the early 1930s, the Welland Canal connecting Lakes Ontario and Erie was reopened. This provided the opportunity for the invasive alewife, *Alosa pseduoharengus*, to expand throughout the Great Lakes. By 1949, alewife had invaded Lake Michigan and quickly established a naturalized population. Decades later, alewife now spawn annually in the open waters of Lake Michigan as well as in tributaries and drowned-river mouth lakes. However, it is unclear to what degree spawning populations are connected via gene flow or if significant population sub-structuring has evolved. During 2022, fin clips of juvenile alewife were collected from several habitats across Lake Michigan. Samples were also collected from Lake Ontario and a small inland lake, Paw Paw Lake, containing a landlocked population that was colonized from Lake Michigan to assess genetic structure in the absence of active gene flow. Extracted DNA from 254 fin clips was sequenced using *SBFI* restriction site associated DNA sequencing (RAD-seq) and 7,218 loci were genotyped. Our results provide evidence that there is very little genetic sub-structure within Lake Michigan indicating that the population remains panmictic. Interestingly, alewife from Lake Ontario were not genetically distinct from Lake Michigan alewife while those from Paw Paw Lake were slightly diverged. Our results imply a large founding population when alewife invaded the Great Lakes and have since experienced low genetic drift likely resulting from large population size and within-lake gene flow.

James Watkins[1], Sarah Lawhun[1], Kayden Nasworthy[1], Toby Holda[2], Taylor Herne[1], Lars Rudstam[1], Anne Scofield[3], Steve Pothoven[4], David Warner[5] and Tim O'Brien[5], [1]Cornell University, [2]Illinois Natural History Survey, [3]US Environmental Protection Agency, [4]National Oceanic and Atmospheric Administration, [5]US Geological Survey. **Lake Michigan Mysids- Continued decline or emerging signs of recovery?**

Mysis diluviana is an important intermediary in Great Lakes food webs, acting as both an important prey item for several fish species and a consumer of smaller zooplankton. Analysis of net-based monitoring data from several agencies recently detected a discouraging trend- mysid populations in Lake Michigan had markedly declined from 2016-2019. Using recent data, we evaluate whether this trend has continued into 2023. There is some reason for optimism in recent years, with successful recruitment and growth of young of year mysid cohorts observed at deep sites. However, there is now a marked contrast between mysid abundances in shallow (< 150 m) versus deeper sites. Site depth has long been a recognized factor influencing mysid abundance, but the expected increase with depth appears to be shifting deeper for Lake Michigan. New platforms such as Saildrones with autonomously collected hydroacoustics provide a high resolution and broader spatial representation of mysid distributions, providing a potential model for future lakewide monitoring.

Ray Watkins, Michael Sayers, Robert Shuchman, Karl Bosse and Reid Sawtell, Michigan Tech Research Institute. **Continuous Monitoring of Nearshore-Bathymetry in the Great Lakes Using Spaceborne LiDAR and High-Resolution Optical Imager.**

Accurate mapping of the nearshore bathymetry in the Great Lakes presents a significant challenge due to the dynamic nature of lake bed changes observed over short temporal scales. Traditional in situ survey methods (shipborne and airborne) are time-consuming and may not capture rapid changes effectively. To overcome this spatiotemporal limitation, this study explores innovative approaches utilizing remote sensing data from spaceborne sensors for continual monitoring of the ever-evolving nearshore bathymetry. Our investigation begins by demonstrating the strong agreement between bathymetric measurements derived from LiDAR data obtained by NASA's ICESat-2 and in situ collected values along satellite flyover tracks. Specifically focusing on a discrete region, Sleeping Bear Dunes in Lake Michigan, we showcase ICESat-2's capability to provide substantial bathymetric data over yearly time scales, resolving depths down to at least one optical depth, approximately 15 meters for Lake Michigan waters. We further emphasize the potential of combining absolute depth scatter data from ICESat-2 with relative depth maps derived from high-resolution optical imagery. This synergistic approach enables accurate and effective nearshore bathymetry mapping in coastal regions on at least a yearly basis. Our findings suggest that the integration of spaceborne LiDAR and optical imagery can serve as a powerful tool for the continuous monitoring and mapping of the dynamic nearshore bathymetry of the Great Lakes, especially in light of the Lakebed 2030 initiative.

Grace Watson, Michael Back, Hana Esber, Emily Carpenter, Kenneth Anderson and Lauren Kinsman-Costello, Kent State University. **Phosphorus Dynamics in the Sediment of a Lake Erie Coastal Wetland.**

Wetlands can act as a filter between the terrestrial land and a body of water, regulating the transfer of nutrients between them. An overabundance of nutrients, such as phosphate, can lead to a harmful algal bloom (HAB), which is known to deplete oxygen from aquatic ecosystems and produce toxins. Our goal was to determine how soluble reactive phosphorus (SRP) flux rates between sediments and surface waters vary across a coastal freshwater wetland when an abundance of phosphate is present in the surface water. We sampled Turtle Creek Bay located in Magee Marsh Wildlife Area, Ohio. We experimentally incubated intact sediment cores with four different SRP concentration treatments based on *in situ* SRP measurements. We found that at ambient SRP concentrations (4.14 ug/L), sediments released 0.455±0.52 mg SRP/m^2/d into surface waters, but when SRP concentrations in the surface water increased (to 18.06, 39.17, and 60.01 mg SRP/L), sediments removed SRP at increasing rates (-0.92±0.28, -2.06±1.00, -7.39±4.27 mg SRP/m^2/d, respectively).The increasingly negative mean flux rates suggest that these coastal wetland sediments can sequester increasing amounts of SRP as surface water concentrations increase.

Meredith C. Watson[1], Shuhuan Li[2], Roland I. Hall[1], Philippe van Cappellen[2] and Fereidoun Rezanezhad[2], [1]Department of Biology, University of Waterloo, [2]Department of Earth and Environmental Sciences, University of Waterloo, ON. **Temporal trends in microplastics deposition to rural reservoirs in the Grand River Watershed.**

Plastic pollution has become pervasive in the environment, raising concern for ecosystem degradation by microplastics (MPs). Studies on MPs within Canadian freshwaters are rapidly emerging, however long-term temporal trends remain largely unknown. Here we report changes through time in microplastic abundance and composition in dated sediment cores from two reservoirs (Belwood Lake and Conestogo Lake) located within an agricultural region of the rapidly

urbanizing Grand River Watershed (GRW). MPs were extracted from 1-cm thick intervals, and quantified and categorized by shape (fragment, fiber, bead). In Belwood Lake, total MP fluxes varied between ~30-500 particles/cm^2/year, with highest values in the 1970s and recent years. In Conestogo Lake, the MP fluxes ranged ~400-1800 particles/cm^2/year, with higher rates since 2011. In both reservoirs, fragments were most abundant, followed by fibers, then beads; with beads notably more abundant in Conestogo than Belwood. Next steps include analysis of extracted MPs by LDIR to determine temporal variation in composition of a subset of particles. The findings will generate new knowledge in changes over time in MPs deposition within the largest watershed in southern Ontario, contributing to Canada's Plastics Science Agenda.

Kerryann Weaver, Environmental Scientist. **Student to sherpa to supervisor - benefiting from the unconventional leadership stylings of Dr. Taylor.**

We all have different definitions for what constitutes a leader and there are many different leadership styles - which vary from person to person. Unconventional leaders are a unique breed of leader, they have the tendency to tackle and engage with issues head on, create awareness, exude accountability and authenticity, and focus on advancing and protecting those they lead - exuding courage, integrity, stewardship, humility, fierce ambition, and empathy. My career path has been anything but conventional, so it is appropriate that I ended up working with an unconventional mentor, leader, and teacher in Dr. Bill Taylor. Our relationship began as one of student - advisor but quickly morphed into a valued mentor-mentee relationship, in which I was respectfully referred to as his sherpa, and to which we shared many great experiences and adventures. My aim is to share our experiences together and how Dr. Taylor's unconventional leadership stylings helped put me on a trajectory towards success.

Thiranya Weerakoon and Catherine Febria, Department of Integrative Biology, University of Windsor. **Evaluating impacts of stewardship on freshwater mussel Species at Risk in the Sydenham River Watershed.**

Habitat stewardship is pivotal in protecting Canada's endangered aquatic species. Various stewardship measures, such as riparian planting and fencing, are meant to mitigate impacts of land use changes and erosion. In practice, local practitioners are responsible for implementing these actions, post-implementation monitoring is rarely supported, especially over longer timescales. Such is the case in the Sydenham River watershed, home to the highest diversity of Unionid freshwater mussels. This research asks: how effective are habitat stewardship actions in mitigating erosion-based impacts on instream Unionid Species at Risk (SAR) habitats? I predict that the quality of riparian buffer zone protection will be a more critical driver of SAR populations than habitat stewardship type, size, or age alone. To evaluate this, I will assess the riparian vegetation, habitat, and soil characteristics, stream water quality, sediment, and substrate composition across 10 previously freshwater mussels surveyed sites, with varying stewardship levels and stream sizes in the Northern and Eastern branches of the Sydenham River. Each site will be quantitatively assessed for streambed grain size analysis, in-stream, and riparian soil nutrients. Variables, including benthic macroinvertebrates and Unionid mussel SAR data, will be analyzed using multivariate statistics. The aim is to assess the extent to which stewardship correlates with in-stream habitat conditions and SAR mussel community composition. The results will provide insight into post-implementation evaluation of stewardship and help guide conservation efforts in the Sydenham River watershed.

Ceci Weibert[1], Alisha Davidson[1], Lindsay Chadderton[2], Andrew Tucker[2] and Theresa Gruninger[1], [1]Great Lakes Commission, [2]The Nature Conservancy. **Great Lakes Invasive Aquatic Plant Control Prioritization and Needs Assessment.**

Jurisdictions in the Great Lakes region identified the need to improve coordination of invasive aquatic plant (IAP) control method research and prioritize needs. Great Lakes resources continue to be compromised and are threatened by the introduction, establishment, and spread of IAP. Numerous agencies, nongovernment organizations and private interests are implementing control measures for IAP and are also working with research institutions and the private sector to develop new tools for management and improve the efficiency and effectiveness of control efforts. Currently, there is no regional approach to coordinate engaged entities, identify needs, share outcomes and lessons learned, and ensure future investments are directed towards the highest priorities. To address this need, the Great Lakes Panel on Aquatic Nuisance Species, with funding support from the U.S. Fish and Wildlife Service via Great Lakes Restoration Initiative, undertook a process to identify and prioritize research needs related to the control of IAP in the Great Lakes region. Through an iterative process, a list of priority IAP species was developed. Literature reviews were conducted for each species, and the species with the greatest knowledge gaps and/or research needs were the focus of a workshop to further discuss species knowledge and needs. This work has culminated in a research agenda outlining the needs for effective control of each priority species, designed to inform both funders and research entities about future work needs.

Dillon Weik[1], Christine Mayer[1], Ryan Young[2], Eric Weimer[3], Lucas Nathan[4], Tammy M. Wilson[5] and John Dettmers[6], [1]University of Toledo, [2]U.S. Fish and Wildlife Service, [3]Ohio Department of Natural Resources, [4]Michigan Department of Natural Resources, [5]United States Geological Survey, [6]Great Lakes Fishery Commission. **Limited Catch: How Back-Calculated Growth Histories for Grass Carp in Lake Erie can Inform Management.**

Invasive grass carp have been captured in Lake Erie since the mid-1980s; however, these fish were assumed to be sterile until spawning was confirmed in 2015. A multi-jurisdictional partnership has been targeting fish for removal with increasing effort since 2018. Grass carp are currently relatively rare, elusive, and difficult to capture. Therefore, supplemental biological data, such as growth histories from age structures, may indicate trends in the population or statuses of individuals. Age was estimated for all fish removed since 2012 using vertebrae, and growth was back-calculated using the Biological Intercept Model. The back-calculated growth was then fitted to a Von Bertalanffy Growth Function. Lake Erie grass carp age structure showed that they don't fully recruit to current removal gears until age-5. Age-at-maturity (as indexed by a decrease in growth rate) of diploid fish was estimated to be 1-2 years. In contrast, literature derived age-at-maturity estimates range from 4-6 years. Consequently, there is potential that recruitment can occur for 3-4 years before fish become fully recruited to current removal gears. Therefore, future efforts devoted to capturing younger fish by exploring alternative habitats or examining new sampling gears may help prevent population growth and the spread of grass carp.

Christopher Weisener[1], Zach Hilbert[1], Danielle Gleason[1], R.Michael McKay[1] and Janis Thomas[2], [1]Great Lakes Institute for Environmental Science, University of Windsor, [2]Ministry Environment, Conservation and Parks. **Exploring the Land to Lake connection linking nutrient dynamics, source identification and ecological function using advance genomics in the western Lake Ontario watershed.**

Some areas of the Great Lakes experience nutrient eutrophication that impair beneficial use and result in harmful effects on ecosystem functions. Challenged by rapid population growth and

land use changes, there is pressing need to safeguard water quality in the western Lake Ontario watershed. There is limited scientific information on the influence of the existing microbial consortia and their contributions to nutrient dynamics in Great Lake watersheds for informed effective management decisions. Efforts are underway to understand both nutrient dynamics and loading to the western basin of Lake Ontario. Currently, target tributaries are sampled for a range of general water quality parameters (e.g., nutrients, *E. coli*, pH, turbidity) and collected year-round, during base- and event-flow conditions. These tributaries span a range of land-use, including large urban areas and Canada's only urban national park. To augment this monitoring work 16S rRNA metabarcoding analysis targeting both the total DNA and active RNA component was applied to water samples collected within a spatial gradient of 11 tributaries. From these samples baseline microbial bioindicators for each large tributary were identified and potential changes in community structures after large rain/precipitation events were compared. Integrating this large genomic data set to understand the land to lake connection will provide additional insight to improve nutrient management for healthy Great Lakes ecosystems.

Katelin Weitzel and Soryong Chae, University of Cincinnati. **Mitigating cyanobacterial harmful algal blooms: water soluble chitosan derivative and clay-based coagulation and flocculation treatment.**

Cyanobacterial harmful algal blooms (cHABs) can lead to concerns regarding water quality, treatment, and public health. Addressing cHABs requires targeted removal at their source to prevent complication in drinking water treatment. Particularly, in-lake treatment methods require environmentally friendly chemicals/materials. Coagulation and flocculation are commonly employed due to their ability to remove whole cells while minimizing the release of cyanotoxins. Although chitosan-assisted coagulation holds promise, its solubility limitations at higher pH values pose challenges in cHAB-prone lakes with pH values above 7. Within this context, this project focuses on addressing cHABs through a treatment approach using a water-soluble chitosan derivative, hydroxyl trimethyl ammonium chitosan chloride (HTCC), in combination with bentonite clay. HTCC functions as a coagulant while clay acts as a flocculant, augmenting the size and strength of flocs. This innovative treatment yields buoyant floc that rises to the water surface after a short settling period. These flocs, laden with cyanobacteria, can then be skimmed off the water surface and removed. This study investigates the interactions between HTCC, clay, and cyanobacteria, proposing a treatment strategy aimed at removing cyanobacteria cells from cHABs-prone lakes and reservoirs.

Christopher Wellen[1], Larissa Gospodyn[2], Cody Ross[3], Kelly Biagi[4], Shanice Rodrigues[1], Janis Thomas[5], Ryan Sorichetti[5], Luke Moslenko[1] and Claire Oswald[1], [1]Toronto Metropolitan University, [2]University of Waterloo, [3]University of Toronto, [4]Brock University, [5]Ontario Ministry of the Environment, Conservation, and Parks. **Integrated catchment science to assess nutrient loss pathways at headwater agricultural basins.**

Improvements in agricultural yields during the 20th and 21st centuries have been responsible for a significant improvement in global standards of living, but have resulted in nutrient pollution of receiving waters. Reducing nutrient pollution requires detailed knowledge of loss mechanisms at watershed scales. This talk will present and integrate work that uses water stable isotope tracers, statistical modelling, and mechanistic modelling to assess nutrient sources and transport from agricultural streams at the headwater scale in Southern Ontario, a cool humid climate with deep till soils. Statistical models show that new water and extreme events are disproportionately responsible for total phosphorus losses from soil, but that loss of dissolved phosphorus appears to have different controls. Mechanistic models can represent stable isotope dynamics reasonably well but

struggle to integrate stable isotope and nutrient dynamics. Overall the results will be informative for scientists and practitioners, and suggest important future research directions.

John Wells[1], Naoshige Goto[2], Xin Liu[3], Takanori Nagano[4], Ilia Ostrovsky[5], Ziwei Zhang[4], Masayasu Irie[4], Syuhei Ban[2] and Dietmar Rempfer[6], [1]Ritsumeikan University, [2]The University of Shiga Prefecture, [3]Guangxi Academy of Sciences, [4]Osaka University, [5]Kinneret Limnological Laboratory, [6]Purdue University Northwest. **Application of Principal Component Analysis to evaluate skill of hydrodynamic simulations in stratified lakes.**

This contribution exemplifies how Principal Component Analysis (PCA) can help validate results from numerical simulations of a stratified lake, and compactly summarize the comparison by extending the well-known Taylor Diagram. PCA is a well-known technique that encodes spatial correlations and has an optimally compressive character. Excepting our earlier contribution (Wells *et al*, SIL Congress 2022), PCA has not been applied to validate simulations in limnology. Consider timeseries of an "observation vector", *e.g.,* the temperatures measured by a thermistor chain. Its PC expansion is a sum of spatially-orthogonal modes, in which the coefficient of each mode evolves in time. The mean-squared error of the truncated PC expansion is minimized at all orders by computing the spatial modes from a certain eigenvalue problem. We consider applications to Lakes Biwa (Japan) and Kinneret (Israel), including currents when observed, and compare the first few modes of the simulation versus observation together with the variance in each mode. To validate the time-varying weights requires a common basis, taken herein as the spatial modes from observations. For analysis of temperatures, especially of the short unsteady record measured in spring in Lake Biwa, we also discuss whether temperature "fluctuations" at each depth should be defined to be differences from the sample mean at that depth, or alternatively as differences from a background "deep, cold" reference temperature. Comparative wavelet analysis of the time-varying coefficients will also be discussed.

Brittany Welsh[1], Erin Bennett[1], Andrew Paterson[2], Ken Drouillard[3] and Julian Aherne[1], [1]Trent University, [2]Dorset Environmental Science Centre, [3]University of Windsor. **Microplastic Distribution during the Ice and Ice-free Period in a Background Headwater Lake, Muskoka, Ontario.**

Microplastics are pervasive contaminants of concern in the environment. Studies have demonstrated that ice formation in marine environments strongly influences microplastic distribution, with concentrations being substantially higher in ice than in the subglacial water, but the influence of ice formation on microplastic distribution in freshwater lakes is relatively unknown. In this study, we examined the distribution of microplastics in a background headwater lake in Muskoka, Ontario, Canada during the ice-free and ice-covered periods to assess the role of atmospheric deposition as a pathway for microplastic transport to freshwaters. Monthly lake samples were collected from the centre of the lake, 1 m below the surface during the ice-free period, with surface grab samples collected three times. During the ice-covered period, under-ice water samples were collected from the from the surface and 1 m below the surface, in addition to snow and ice samples from the surface of the frozen lake. A sub-set of the snow, ice, and under-ice lake water samples were also collected for dissolved organic carbon content to assess the source contribution. Results show that microplastic concentrations were statistically higher in snow and ice compared to lake water but similar concentrations were observed in lake water during the ice-free and ice-covered period. During the ice-free period, microplastic concentrations displayed a vertical distribution down the water column with the highest concentration in the hypolimnion.

Phillipe Wernette and Peter Esselman, USGS, Great Lakes Science Center. **Improving Benthic Habitat Mapping with Photogrammetry and Machine Learning.**

Comprehensive benthic mapping relies on a suite of platforms, sensors, and techniques. Benthic imagery from ROVs and AUVs can provide valuable ground-truth data over large areas but often result in massive data volumes which can present analytical challenges. This research explores the application of photogrammetry and machine learning to effectively process benthic images into high-resolution orthomosaics for ground-truthing and benthic habitat assessment. Orthomosaics derived from structure from motion (SfM) were then input into a series of machine learning utilities for mapping different components of the benthic habitat. The full-resolution orthomosaic reduced data volume substantially compared to the large number of individual AUV images, suggesting SfM may provide a valuable tool for developing spatially-continuous benthic maps and reducing data product volume. An added benefit of SfM is its ability to produce a dense cloud of points with geospatial location and color, which can further aid in benthic mapping and characterization by providing 3D habitat structure information. The combination of underwater photogrammetry and machine learning can enhance existing workflows for lakebed mapping and underwater spatial ecology.

Andrew White, Shadi Moradi, Phillipe Wernette, Joseph Geisz, Alden Tilly, Nicholas Yeager, Scott Dwyer, Luke Saylor, Daniel Monhollen and Peter Esselman, Great Lakes Science Center, United States Geological Survey. **Benefits, Limitations, and the Future of Manual Image Labeling for Great Lakes Research.**

Manual digital image labeling is a critical step in the development of datasets to train machine learning models for the automatic detection and quantification of features in underwater images. Extensive manual image labeling has been conducted at the U.S. Geological Survey in recent years to support the development of machine learning models to classify lakebed substrates, identify round goby, determine underwater image quality, and detect different types of nuisance algae. Inaccuracies in the labeling process—whether focused on whole-image class designation or within-image tracing of features or dot annotation—can lead to inaccuracies in the machine learning algorithms trained from the data, and can also cause challenges for assessing model performance. We present lessons learned over five years of effort and describe best practices for image labeling processes. One of these lessons is that images labeled by a single individual can be prone to error and bias, leading us to develop procedures that use consensus-based methods that compare results of three or more labelers for a single image. The increase in effort to label each photo is offset by greatly improved data quality (i.e., reduced uncertainty), improved model performance, and improved model evaluation. We present major challenges to the labeling process including image degradation, how to handle discrepancies between multiple labelers, ambiguous features, and biases associated with labeler subjectivity.

Elizabeth Whitmore-Stolar[1], Joseph Connolly[1], Christopher Marshall[1], James Watkins[1], Nitin Vincent[2], Michael Pfrender[2] and Lars Rudstam[1], [1]Cornell Biological Field Station, [2]University of Notre Dame. **Utilizing metabarcoding and traditional taxonomy to evaluate zooplankton community structure.**

In the Laurentian Great Lakes, the zooplankton biomass and community structure are important factors in the lower food web. Identification of zooplankton species with traditional methods can be difficult and is not possible for some life stages with current taxonomic keys. Metabarcoding can help provide insight into the genetic diversity and different genetic adaptations amongst the different lakes. Metabarcoding methodology involving sequencing cytochrome c

oxidase *I* (COI) genes collected from multiple species within a bulk DNA sample was employed. Samples were collected as part of the Great Lakes National Program Office (GLNPO) summer monitoring program of the Laurentian Great Lakes. Wisconsin zooplankton nets were used to sample 30 sites across all 5 lakes. The samples were analyzed via traditional taxonomy and then subsamples were taken and analyzed via standard metabarcoding techniques. The COI genes present in the bulk samples were isolated, amplified, sequenced, and analyzed to provide community structure data to compare to the traditional taxonomy analysis. The results of both were combined to accurately give a characterization of the summer zooplankton community structure across all Laurentian Great Lakes. We think that combining these two methodologies we can strengthen our understanding of the Laurentian Great Lakes zooplankton community and it will improve the understanding of species diversity and help detect new non-native species.

Brittany Zepernick[1], Emily Chase[1], Elizabeth Denison[1], Naomi Gilbert[2], Alexander Truchon[1], Thijs Frenken[3], William Cody[4], Robbie Martin[1], Justin Chaffin[5], George Bullerjahn[6], R. Michael McKay[7] and **Steven Wilhelm**[1], [1]The University of Tennessee, [2]Lawrence Livermore National Lab, [3]HAS University of Applied Sciences, [4]Aquatic Taxonomy Specialists, [5]The Ohio State University, [6]Bowling Green State University, [7]GLIER, University of Windsor. **Declines in ice cover coincide with light limitation responses & community change in freshwater diatoms.**

Lake Erie experiences expansive cyanobacterial Harmful Algal Blooms (cHABs) most summers. Yet these summer cHABs represent just a subset of the seasonal algal bloom cycle of Lake Erie. Diatom blooms manifest throughout the early winter - late spring. Though it is known winter blooms can surpass summer cHABs in biovolume and have been linked to summer hypoxia, they remain widely unstudied. Moreover, with ice cover at a record low across the Great Lakes, many are asking how these psychrophilic diatoms (such as *Aulacoseira islandica* and *Stephanodiscus* spp.) will respond to an increasingly ice-free water column. We addressed this research gap by conducting a large-scale metatranscriptomic analysis of the winter water column. Samples span spatial, temporal and climatic gradients, encompassing "high ice cover" and "low ice cover" periods. The results demonstrated declining ice cover altered diatom community composition and provided evidence of light limitation in diatoms sampled from the ice-free water column. Further, we identify two gene families which serve to increase diatom fitness in the ice-free water column. This included changes in proton-pumping rhodopsins (a potential second means of light-driven energy acquisition) and fasciclins (a means to "raft" together to increase buoyancy and co-locate to the surface to optimize light acquisition).Our observations provide insight into how diatoms respond to dynamic ice conditions of today and how they will fare in a climatically altered tomorrow.

Kathleen Williams[1], Meghan Klasic[1], Kathryn Mika[2] and Paul Seelbach[3], [1]United Stated Environmental Protection Agency, [2]Michigan Department of Energy, Great Lakes, and Environment, [3]Retired. **Exploring what it means to center communities in Great Lakes restoration and ecosystem-based management programs.**

Whereas once restricted to technical and management actions to improve the environment, the concept of 'ecosystem restoration' has begun to be reframed across the US and the globe to include activities that explicitly acknowledge human relationships with nature. More attention is being directed at involving local communities in regional landscape restoration and conservation for planning, as well as long-term stewardship. The goal of these efforts is to enhance the resilience of communities and ecosystems to increasingly challenging stressors, such as legacy contamination, climate change effects, severe weather, and economic instability. Questions remain about the most effective arrangement of humans and organizations to achieve this goal in ways that recognize the

complexity of resilience for both ecosystems and people. A gathering of social scientists was held in Ann Arbor, Michigan in May 2023 to try to answer these questions. The goals of the workshop were two-fold: to identify the social outcomes that can be achieved through environmental programs, and to identify the recommendations and strategies that will lead us to those outcomes. This presentation will provide and overview of the methodology used in the workshop, as well as the results and next steps. *The views expressed in this presentation are those of the authors and do not necessarily represent the views or the policies of the U.S. Environmental Protection Agency.*

Nathan Wilson, Lakehead University. **Cyanobacteria Blooms in the District of Thunder Bay: A Growing Concern for Freshwater Ecosystems.**

Cyanobacteria blooms are happening more, not only in heavily developed regions but in lakes where blooms were not expected to be an issue. Changes in climate patterns, i.e., drier periods followed by heavy rain, later ice on and earlier ice off, along with increasing expansion of human activity in watersheds will likely result in more bloom events. On the North Shore of Lake Superior, the general public of Thunder Bay are not overly familiar with cyanobacteria blooms in the freshwater lakes of the region. Lakes in Northwestern Ontario are assumed to be Oligotrophic, minimally impacted lakes. Spring phosphorus monitoring data shows that the region's lakes are not experiencing excessive nutrient inputs with the average Spring TP for 110 lakes being 13.28 ug/L. Yet, there are 13 lakes in the Thunder Bay region that have had confirmed cyanobacteria blooms in the last 4 years. Public reporting is essential to provide outreach and training for communities to identify and report bloom frequency and emerging indicators. Seasonal monitoring during both ice on and ice off is also critical to understand the yearly nutrient cycle of these freshwater lakes.

Christopher Winslow[1], Kristen Fussell[1] and Thomas Bridgeman[2], [1]Ohio State University, [2]University of Toledo. **Ohio's Harmful Algal Bloom Research Initiative: Lessons Learned and Gaps to Address.**

A high-level glimpse into ~100 harmful algal bloom (HAB) research projects funded by Ohio's Department of Higher Education (ODHE). These research efforts aim to: (1) improve detection of HABs and an understanding toxin production (e.g., evaluating the impact of rivers on phosphorus delivery to Western Lake Erie); (2) assess the health impacts of HABs and their associated toxins (e.g., new laboratory methods to detect the presence of algal toxins and their byproducts in living tissue such as blood and laboratory studies on the effects of algal toxins at the cellular level and beyond); (3) develop and test new treatment methods for contaminated drinking water (e.g., Laboratory testing of water treatment methods that give treatment facilities effective and cost-efficient options for clearing out algal toxins using their current infrastructure); and (4) assess the ability of land use changes to reduce nutrient inputs into aquatic ecosystems (e.g., Establishment of connections between various land management practices upstream and nutrient flows downstream). Since 2015, ODHE HAB Research Initiative has been a statewide response to the threat of HABs and is now informing on the ground H2Ohio efforts. These projects are intended to help state agencies prevent and manage future algal issues. Arguably, these projects have positioned Ohio as a leader in understanding this emerging global threat.

Anya Wojciechowski and **Asha Wojciechowski**, Monta Vista High School. **Ecological Challenges and Potential Mitigations for a Great Lakes Ultra-large Pumped Storage System.**

North America has the potential to host the World's largest pumped hydro energy storage system by transporting large volumes of water between Lake Erie and Ontario, to support achieving 100% green electricity by 2035. This preliminary research outlines possible ecological impacts

brought upon by a hydro energy storage system at the scale proposed, for both construction and operation project phases. Possible mitigation strategies are also identified. Initial research to identify species that may be at risk will be presented, as well as potential effects on the shoreline and shallow regions of the Great Lakes. Our findings suggest that it is inevitable that certain threatened and endangered species will be affected to some extent and require mitigations to meet ecological standards. One of the options that we concluded would help mitigate the risk of aquatic life from being harmed by the turbines were fish screens, arranged in a specific array and position. For the construction phase, we propose silt curtains made of certain materials to contain the majority of silt from tunneling and excavation. Further research is needed to develop a comprehensive understanding of ecological risks and optimized mitigation solutions. The ability of the lake ecosystems to safely coexist with the proposed pumped hydro energy storage system is essential to enable a roadmap to implementation of such an ambitious renewable energy solution while achieving high standards of environmental stewardship.

Nicole Wood, University of Syracuse. **Science Communication vs Science Misinformation: A review and a call to action.**

In the past several years, we have seen science misinformation take hold of various demographics throughout multiple countries impacting how populations interact with science. This uptake of misinformation has deterred positive public health outcomes, effective environmental policy implementation, and more. With distrust in media and institutions growing rapidly in segments of society, driven by dissemination via social media platforms, science communication strategies need to be implemented that will effectively meet the needs of individual demographic assemblages. Science communication has been shown as a successful means of engagement with non-science audiences to distribute scientific knowledge, but now communicators need to dive deeper into this emerging field of science to solve what some are calling the greatest crisis of our time. This review will look at drivers behind the growth of misinformation, how it impacts all fields of science, the successes of quality science communication, and the places where research is most needed to provide data-driven applications to reduce misinformation in our society.

Jiayi Wu and Kim Cuddington, University of Waterloo, Department of Biology. **Predicting Black Carp (Mylopharyngodon piceus) age at first sexual maturity in different environments with temperature.**

Black Carp (*Mylopharyngodon piceus*) is one of the four invasive Asian Carp species (Bighead Carp, *Hypophthalmichthys nobilis*; Grass Carp, *Ctenopharyngodon idella* and Silver Carp, *Hypophthalmichthys molitrix*) in North America. As benthic predators, Black Carp pose potential risks to the Great Lakes' great diversity of unionids and could bring potential changes to the local benthic communities. Therefore, predicting population growth rate of the species in novel conditions is important. Fish age at first sexual maturity is negatively correlated to the maximum per capita population growth rate, thus can be used to estimate potential population growth for invasive species. Previous studies have shown a significant negative relationship between age at maturity and temperature for all three other Asian Carp species, but not for Black Carp. With a more comprehensive dataset, we demonstrated that the same relationship exists for Black Carp as well. Average winter air temperature is the best predictor of Black Carp age at maturity; followed by average winter water temperatures. This significant relationship between age at maturity and temperature was not altered in artificial growing environments. Our results suggested that for capital breeders such as Black Carp, temperatures in the winter months are more important for their energy accumulation and

maturation, and may determine invasion risk in northern locations, such as tributaries of the Great Lakes.

Donald Wuebbles[1], Anne Stoner[2], Katharine Hayhoe[3] and Kenneth Kunkel[4], [1]University of Illinois, [2]Earth Knowledge, Inc., [3]The Nature Conservancy, [4]North Carolina State University. **A High-Resolution Climate Impacts Analysis for the Great Lakes Region.**

Over the last two centuries, the Great Lakes and the regions around them have been significantly impacted by human activity. Climate change is now adding more challenges and another layer of stress to both the region and the Great Lakes themselves. Observed changes in temperature and precipitation, including both annual and seasonal averages and extremes such as heatwaves, heavy downpours, floods, and droughts, are already affecting both human and natural systems. These impacts are expected to continue in the future, and high-resolution climate projections provide crucial insights into assessing future climate risk and developing climate resilience strategies. Yet for many practitioners and stakeholders, currently available options are limited in quality, scope and/or geographic coverage. The Seasonal Trends and Analysis of Residuals empirical statistical downscaling model (STAR-ESDM) is a new, computationally-efficient and flexible approach to generating high-resolution climate projections. In this study, we analyze current and projected changes in climate in the region of the Great Lakes, with a particular focus on temperature and precipitation and extreme events, using STAR-ESDM both for the United States and Canada, with a particular focus on temperature and precipitation and extreme events. This study also draws on the array of existing research to assess how these changes are affecting the Great Lakes. It provides useful input to policy- and decision-making for the region looking forward to anticipate projected changes and corresponding societal risks.

X

Qianqian Xiang[1], Mengdie Li[1], Wenyu Long[1], Ruisi Yang[1] and Xuexiu Chang[2], [1]Yunnan Collaborative Innovation Center for Plateau Lake Ecology and Environmental Health, College of Agronomy and Life Sciences, Kunming University, [2]Great Lakes Institute for Environmental Research, University of Windsor. **Metabolic profiling of Polystyrene nanoplastics toxicity in the gills of Acrossocheilus yunnanensis.**

Due to their potential risk to the ecological environment and human health, the ecotoxicity of nanoplastics is of concern. Although the adverse effects of nanoplastics in fish gills have been widely reported, their toxic mechanisms remain unclear. The aim of this study is thus to elucidate the mechanism of toxicity in the gills of *Acrossocheilus yunnanensis* following exposure to two concentrations of Polystyrene nanoplastics (0.1 μg/mL, 0.1_PS-NPs, and 10 μg/mL, 10_PS-NPs) using metabolomics based on non-targeted liquid chromatography and mass spectrometry. The results showed that 0.1_PS-NPs and 10_PS-NPs induced 75 and 164 differentially expressed metabolites in the gills of *A. yunnanensis*, respectively. These metabolites mainly involved lipid metabolism, amino acid metabolism, and carbohydrate metabolism pathways. The differential metabolites induced by 10_PS-NPs compared with 0.1_PS-NPs were not only significantly enriched in the glycerophospholipid metabolism pathway, but also in the sphingolipid metabolism, and nucleic acid metabolism pathways. Further examination found that both 0.1_PS-NPs and 10_PS-NPs can cause the proliferation of gill epithelial cells. These results suggest that PS-NPs induced lipid metabolism disorders, which affected the phenotype in the gills of *A. yunnanensis*. The findings

of this study provide novel perspectives for understanding the toxic mechanism of nanoplastics in fish gills.

Dan Xiao, Tristhal Parasram, Christian Notte, Michael Mouawad, Lily Symons and Sam Connell, University of Windsor. **Magnetic Resonance Imaging (MRI) for Agricultural Applications.**

Magnetic resonance imaging (MRI) is widely recognized as the most flexible and powerful non-invasive diagnostic imaging technique. MRI can visualize the internal structure of biological systems by mapping the spatial position of water, offering rich soft tissue contrast. It can be applied to study agricultural systems, including fruits, stems, and roots. Conventional MRI cannot be translated into field measurements due to the siting and cryogenic constraints of the superconducting magnet. Constructing a portable MR scanner to study plant development in situ is particularly advantageous, providing a direct means to explore plant physiology and enhance yield. In this presentation, I will introduce MRI, emphasizing its agricultural applications and highlighting our recent work on portable magnetic resonance.

Qin Xin, Hena Farooqi, Nayereh Saborimanesh, Nicholas Utting and Jaiden Lang, CanmetENERGY Devon. **Bio-derived oils can have different behaviour and toxicity when spilled into waters.**

The global demand for bio-derived oils and chemicals which are classified as hazardous and noxious substances is steadily growing. With the increasing variety of bio-feedstocks and advancement on process technologies, the properties of commercially transported bio-derived oils vary significantly. Consequently, there are knowledge gaps of how these variations affect their fate, behaviour and impact to the ecosystem when accidentally released into aquatic environments. The objective of this study is to investigate how the different chemical and physical properties of a series of bio-derived oils and petroleum fuels affect the fate and behaviour in both fresh and salt waters. Results from baffled flask tests showed that most tested bio-derived oils floated and dispersed similarly to petroleum fuels when spilled into water. One exception to this, was a category of oils derived from the pyrolysis process of biomass at temperatures exceeding 300°C, which sunk in both fresh and salt waters and resulted in the highest dissolved organic contents as well as a significantly altered basic chemistry in both waters when compared to other tested oils. The results of Microtox assay showed that a toxicity decrease of waters contaminated by pyrolysis oils, followed by various diesels (*i.e.*, biodiesel, renewable diesel and petroleum diesel), and non-toxic by vegetable oils. Week-long meso-scale tank tests were conducted to fill further gaps of the weathering effect on the behaviours of bio-derived oils in near-shore water environments.

Yan Jin Xu[1], Razegheh Akhbarizadeh[1], Freya Boerner[1], Paul Helm[2, 3] and Miriam Diamond[1, 3], [1] Department of Earth Sciences, University of Toronto, Toronto, [2]Environmental Monitoring and Reporting Branch, Ontario Ministry of the Environment, Conservation and Parks, [3]School of the Environment, University of Toronto, Toronto. **Microplastic Extraction Methods in Complex Water Samples- Effects on Aged and Pristine Microplastics.**

Harmonized methods for optimal extraction of microplastics (MP) from surface waters containing considerable complex natural organic matter are needed that also consider aged in addition to pristine MP. We report on a systematic study of extraction procedures to effectively remove unwanted organic matter (OM) while balancing the retention of aged and pristine MP. Sequential combinations of oxidative-alkaline protocols (e.g., potassium hydroxide, hydrogen peroxide, Fenton's reagent) were applied to polymeric particles (olefins, polystyrene, polyamide, polyesters, tire rubber) of various shapes and sizes from 63 to 1000 µm with and without OM.

Recoveries of MPs from digested water samples depended on the polymer type, aging, and shape. Recoveries of easily degraded aged particles (e.g., polyurethane and polystyrene foams, polyester fibers) were up to 6 times lower than that of their pristine version after applying the same digestion method (2-35% vs. 12-79% after alkaline-oxidative digestion without OM). A Response Optimization Model indicated that, for OM concentrations <2 g/L, using a single-step digestion method can minimize MP losses while effectively digesting OM. Samples with OM concentrations exceeding 10 g/L require a sequential combination of two or more digestion solutions to balance efficiency and effectiveness while minimizing MP losses, especially for the highly weathered MP. Adding recovery spikes of known MP with OM prior to digestion is highly recommended, while both chemical characterization and morphometric methods are recommended to evaluate the MP degradation

Pengfei Xue[1], Chelsea Schelly[1], Ana Dyreson[1], Thomas Oommen[2], Jenny Apriesnig[1], David Watkins[1], Jiali Wang[3], Rao Kotamarthi[3], Thomas Wall[3], Rachael Pressley[4], Evan Lanese[4], Jobin Thomas[2], Miraj Kayastha[1] and Chuyan Zhao[1], [1]Michigan Technological University, [2]THE UNIVERSITY OF MISSISSIPPI, [3]Argonne National Laboratory, [4]Western Upper Peninsula Planning Development Region. **Enhancing Rural Resilience in the Great Lakes: The C-CHARM Initiative.**

The Center for Climate-driven Hazard Adaptation, Resilience, and Mitigation (C-CHARM) is a transformative initiative addressing the vulnerabilities of underserved communities in the Great Lakes region, focusing on the Western Upper Peninsula of Michigan. C-CHARM brings together interdisciplinary expertise to address the particular challenges posed by climate-related hazards and low resilience in this area. Leveraging a fully coupled atmosphere-land-lake model, the project focuses on developing high-resolution climate information for historical and future periods to understand climate change impacts on geohazard risks and energy system disruptions, and their socioeconomic impacts at local scales. Additionally, C-CHARM establishes an Integrated Technology Ecosystem (ITE) to empower non-technical individuals, planners, and decision-makers in local and Tribal governments, fostering awareness of projected climate conditions and supporting climate risk-informed analyses for effective adaptation decision-making. Centered on a co-production approach, the project collaborates closely with local governments and communities to identify barriers to adaptation and implement strategies for climate resilience. The overarching goal is to use a community-centered approach to connect climate change and extreme events to the local rural communities' needs for climate resilience. Anticipated outcomes include expanded microclimate research, strengthened regional capacity in climate resilience, and emphasizing actionable strategies derived from the integration of science and community engagement.

Y

Alexa Yeo[1], Eric Anderson[1], Christiane Jablonowski[2], David Wright[3], Ayumi Fujisaki-Manome[4], Bryan Mroczka[3], Daniel Titze[3] and Greg Mann[5], [1]Hydrologic Science and Engineering, Colorado School of Mines, [2]Climate and Space Sciences and Engineering, University of Michigan, [3]Great Lakes Environmental Research Laboratory, National and Oceanic and Atmospheric Administration, [4]Cooperative Institute for Great Lakes Research, University of Michigan, [5]National Weather Service WFO-Detroit, National Oceanic and Atmospheric Administration. **Assessing the Potential for Medium-Range Ice Forecasts in the Laurentian Great Lakes.**

Real-time and forecasted ice information in the Great Lakes is critical for essential operations, such as ice breaking, commercial navigation, search and rescue, and oil spill response. Existing forecast products for the lakes are not available for medium-range time horizons (5-16 days out), yet they could provide important information for decision making, particularly for ice breaking and spill responses. In addition, Great Lakes ice forecasts at these timescales could be important for Medium-Range Weather (MRW) forecasting. However, the skill of existing operational products in predicting ice conditions at MRW timescales is not currently known. This project aims to determine how well ice and hydrodynamic forecasts from a coupled ocean-ice model (FVCOM-CICE) perform for MRW forecast horizons. MRW forecasts of ice and temperature using NOAA's Great Lakes Coastal Forecast System (GLCFS) will be driven by NOAA's Global Forecast System (GFS) and compared to observed conditions from the National Ice Center (NIC). Simulations were carried out for the 2022 ice season, using 8 different MRW (16-day) forecast periods. Forecast results were compared to baseline observations of meteorology and nowcast ice conditions using standard skill assessment metrics. Results show the potential for MRW ice forecasts in the Great Lakes. These findings could inform the extension of existing Great Lakes operational models and the potential of lake-atmosphere coupling for the Unified Forecast System (UFS).

Jim M. C. Young and Geoffrey Gunn, Canada Water Agency. **The National Freshwater Data Strategy: Connecting water data across Canada.**

Launched in June 2023, the Canada Water Agency aims to improve freshwater management in Canada by providing leadership and improved coordination to proactively address freshwater challenges and opportunities. To this end, among other priorities, the Agency is developing a National Freshwater Data Strategy with Indigenous partners, provinces and territories, environmental organizations, and others. The data strategy will outline shared principles and approaches to make freshwater data more interoperable and accessible, and thus support decision-making across Canada. In this presentation, Agency staff will provide more details on the strategy and the path forward on its development.

Fasong Yuan and Emilia DiBiasio, Cleveland State University. **Remarkable resilience of Lake Erie carbon dynamics attributed to carbonate weathering?**

Over the past century Lake Erie has undergone major ecosystem changes from anthropogenic and hydroclimatic forcings. However, concentrations of dissolved inorganic carbon (DIC) from the USEPA long-term water quality monitoring data have remained at a relatively constant level of 22.1 ± 1.4 mg/L since the early 1980s, comparable to those measured in the 1906-07 and 1970s. Here, we present chemical and isotopic results from water samples taken from Lake Erie during the USEPA R/V Lake Guardian cruises in April and August of 2023. Our results show that $d^{13}C$ of DIC ($d^{13}C_{DIC}$) increased abruptly from the western to central basin. The increase in $d^{13}C_{DIC}$ was more pronounced in spring than in summer, coinciding with an appreciable (2 mg/L) increase in DIC concentrations from the western to central basin. The concurrent increases in DIC and $d^{13}C_{DIC}$ cannot be explained by biological processes (primary production less respiration), suggesting an influence of DIC from dissolution of carbonate minerals from tributary inputs, coastal erosions, and in-lake formations. Moreover, $d^{13}C_{DIC}$ of the lake's epilimnetic waters is mostly not far from atmospheric equilibrium. Opposing to significant trends of decreasing $d^{13}C_{DIC}$ as observed from atmospheric CO_2 and oceanic waters, historical isotopic data from the lake reveals that $d^{13}C_{DIC}$ has not changed much over the past half a century. Collectively, these data suggests that Lake Erie carbon dynamics is remarkably resilient due to carbonate weathering and buffering.

Z

Sophia Zamaria[1] and George B. Arhonditsis[2], [1]University of Toronto, [2]University of Toronto Scarborough. **Towards comprehensive calibration of a SWAT model for agricultural watershed management in the Lake Erie basin: Irrigation scheduling models.**

In agriculturally predominant watersheds, irrigation substantially influences the water balance and water quality. The Soil and Water Assessment Tool (SWAT) is often used to evaluate management decisions on streamflow and water quality and allows users to simulate irrigation practices at small scales using either a default auto-irrigation routine or a manual irrigation schedule. Most SWAT irrigation studies use the auto-irrigation routine, although flaws arising from this method have been documented. Irrigation in a watershed can be spatiotemporally variable due to differences in farmers' approaches to irrigation practices, such as the type of irrigation system used and timing of irrigation, which the SWAT auto-irrigation routine is unable to account for. Data on irrigation in Ontario is limited as irrigation water takings and water applied are not publicly available. These issues make it difficult to determine the influence of irrigation on the water budget and implement informed agricultural and water resource management decisions. However, studies that manually develop irrigation schedules that consider spatiotemporal variability in SWAT have demonstrated better representation of irrigation practices and result in improvements in the characterization of evapotranspiration and flow. Building off previous work, we introduce new irrigation schedule models that consider soil moisture and precipitation in addition to spatiotemporal variability. Our preliminary results demonstrate that our spatiotemporally heterogenous irrigation scheduling model results in better characterization of baseflow and model improvement in the agricultural Big Creek Watershed, ON.

Corey M. Zanatta, Andrew J. Wiebe and David L. Rudolph, University of Waterloo. **Using extended point temperature reconnaissance to understand groundwater discharge into Alder Creek, SW Ontario.**

Groundwater discharge into streams is important to the Laurentian Great Lakes from water quality and water quantity perspectives. However, a thorough understanding of groundwater flow patterns and geochemical quality is difficult because fluxes through the streambed and constituent concentrations are likely to vary spatially and seasonally. This is particularly important in watersheds such as the Alder Creek watershed (70 km^2) within the Grand River basin, where non-point source contaminants such as nitrate and road salt are concerns, and where multiple public supply wells must balance withdrawals of groundwater with maintaining ecosystem needs. Consistent ambient groundwater temperatures in this area indicate that heat may be used as a tracer in summer or winter to identify locations of moderate to rapid groundwater discharge. In this study, manual point measurements of stream and streambed (~20 cm depth) temperatures were collected in association with handheld IR camera photos during the summer along 18 km of the Alder Creek stream network, about 20% of the total length. The field data were useful to identify clusters of cold temperature measurements suitable for detailed instrumentation related to flux and geochemistry. Manual point measurements are typically used along shorter reaches and do require significant operator time, but this study suggests that they may be used to characterize a substantial portion of a watershed's perennial stream network in terms of likely and unlikely groundwater discharge reaches.

Brittany N. Zepernick[1], Emily E. Chase[1], Veronica Brown[2], Laura Smith[1], Alexander R. Truchon[1], Robbie Martin[1], Jack H. Cheshire[3], Hans W. Paerl[3] and Steven W. Wilhelm[1], [1]Microbiology Department, University of Tennessee, [2]Genomics Core, University of Tennessee, [3]The Institute of Marine Sciences, University of North Carolina Chapel Hill. **The Other Algal Bloom Problem: Elucidating Effects of Cyanobacterial Induced "Lake Basification" on *Microcystis* spp.**

Cyanobacterial Harmful Algal Blooms (cHABs) are well-known for their prolific biomass accumulation and cyanotoxin production. Research has revealed cHAB ecological success is spurred by factors including anthropogenic nutrient loading and elevated temperatures. Yet, one factor that has remained absent from the discussion is their ability to manipulate water column pH *(i.e.,* by rapidly consuming $CO_{2\,(aq)}$). Elevated pH conditions have been widely recorded - yet seldomly investigated - in the literature. While we now know cHABs drive water column pH from 7.7-8.2 to 9.2-10 in various freshwater systems, we know little concerning how this affects the cyanobacteria and their competitors. Here, we investigated how alkaline pH levels alter transcription patterns and physiology of cyanobacteria (*Microcystis aeruginosa)* in continuous laboratory cultures. Chemostats were maintained at pH 7.75 to establish baseline physiology then shifted to pH 9.25. To this end, we were able to monitor both the transition to higher pH conditions as well as the new "steady-state" physiology of the cells. In conjunction with our previous efforts, our work has demonstrated how *Microcystis* driven changes in pH provide a competitive advantage that enables cyanobacteria to exclude competitors (*e.g.,* diatoms) while serving as a potential positive feedback loop for these cyanobacteria during late-stage bloom maintenance. Going forward, understanding the shifts in both biology and chemistry that occur during these contrasting conditions is necessary in the development of management strategies for cHABs

Hongyan Zhang[1], Doran Mason[2], Ed Rutherford[2], David Cannon[3], Nicholas Boucher[4], Ayumi Fujisaki-Manome[3], James Kessler[2], Elizabeth Fulton[5] and Jia Wang[2], [1]Eureka Aquatic Research, LLC, [2]NOAA Great Lakes Environmental Research Laboratory, [3]University of Michigan Cooperative Institute for Great Lakes Research, [4]Michigan State University Department of Wildlife and Fisheries, [5]CSIRO Oceans & Atmosphere. **Climate Change Effects on the Lake Michigan Food Web: A Linked Earth System Model Approach.**

Climate change may exert varied impacts on aquatic ecosystems. Rising temperatures can extend growing seasons, enhancing productivity, but potentially reducing optimal habitats for cold-water species. Changes in large lake hydrodynamics, driven by climate change, can alter nutrient and plankton distribution. In Lake Michigan, already impacted by invasive dreissenid mussels, we used a linked earth system model to explore temperature and hydrodynamics effects on its food web. Climate scenarios (cold, normal, warm) were represented by hydrodynamic model output, including water temperature, water exchange and vertical mixing coefficients, from warm, normal, and cold years during 1994-2021. Simulations covered 100 years under different climate scenarios from 2021 onwards. Compared to the normal temperature scenario, the cold scenario featured higher vertical mixing rates and lower temperatures during the growing season, while the warm scenario had lower vertical mixing rates and higher temperatures during the growing season. Simulations revealed that mussels had stronger food web effects than did climate variation. Invasive mussel biomass was highest under the normal scenario due to an optimal combination of algal growth and delivery by mixing to benthic mussels. Model group changes under different climate scenarios involved tradeoffs in predator-prey interactions, hydrodynamic mixing effects on nutrient and plankton distributions, and temperature effects on growth and metabolism. Our study emphasizes the need for more numerical studies to discern clear trends or potential regime shifts in aquatic ecosystems resulting from climate change.

Kejia Zhang[1], Cheng Cen[2, 3], Tuqiao Zhang[1], Youwen Shuai[2] and Xinwei Mao[1], [1]Innovation Center of Yangtze River Delta, Zhejiang University, [2]Zhejiang University, [3]Nibo University. **Research on odor-producing response mechanism of freshwater algae under stressful conditions and the corresponding control technologies.**

This study selected typical types of adversity faced during the water supply process, including stress from meteorological factors, emerging-pollutants, and water treatment. For natural meteorological stress such as temperature variability, the study quantitatively analyzed the temporal impact of temperature on odor production, and utilized the fluorescent characteristics of extracellular organic matter to assist in predicting odor outcomes. For stress from emerging-pollutants such as microplastics, it elucidated the key pollutant features and common rules that trigger odor risks based on acute exposure tests involving multiple odor-producing algae. For pre-oxidation stress in water treatment, the study aimed at optimizing algae treatment effectiveness and minimizing odor risks, clearly defining the implementation plans and principles for moderate pre-oxidation for simultaneous algae and odor removal. The main conclusions were as follows: Under thermal stress, the results showed that both temperature and temperature variability could affect the odor-producing behaviors of algae, and the impacts were not limited to the day of exposure but had persistent and delayed results. Under the stress from emerging pollutants as represented by microplastics, the results showed that microplastics with particle sizes of 100 nm, 1000 nm, and 10 μm could induce different levels of overall odor responses when coexisting with four types of odor-producing algae. Under exogenous oxidative stress, the results showed that different peracetic acid pre-oxidation-enhanced coagulation processes exhibited different performances in terms of coagulation effects and release of odorants.

Yongwang Ren[1], Xibo Wan[2], **Ruohao Zhang**[1], Wendong Zhang[3] and Jiameng Zheng[4], [1]Pennsylvania State University, [2]University of Connecticut, [3]Cornell University, [4]University of Illinois Urbana-Champaign. **The Silent Threat: Assessing and Mapping PFAS Risks in Three Great Lake States.**

As awareness grows about the potential health impacts of Per- and poly-fluoroalkyl substances (PFAS), there is increasing interest in their regulation. However, it remains unclear which communities are affected by PFAS exposure. This lack of clarity, partially due to insufficient data, affects our understanding of PFAS's geographical spread and intensity, a critical issue especially for vulnerable and socially disadvantaged communities. This project integrates public PFAS monitoring data with novel GPS cell phone location data and consumer food consumption datasets to measure community risks associated with PFAS pollution from environmental sources across three Great Lake states: Michigan, New York, and Pennsylvania. We quantify the PFAS exposure at the 5-digit zip code level from four major pollution sources: i) Industrial Emissions, ii) Drinking Water, iii) Recreational Activities, and iv) Seafood Consumption. Each zip code is categorized into one of five risk levels for each factor: minimal, low, moderate, high, and severe. By considering all risk factors together, we develop an overall PFAS community risk index and generate a mapping tool for policymakers and communities to identify their PFAS exposure risks. Preliminary results suggest a large heterogeneity in PFAS risks across the three states. PFAS risk from drinking water is highest in New York, with a mean of 1.2 ng/L, and lowest in Michigan, with a mean of 0.14 ng/L. Drinking water PFAS risks also vary within states across counties.

Shuting Zhang[1], Yuanyan Zi[2], Justin Barker[2] and Xuexiu Chang[1], [1]Yunnan Collaborative Innovation Center for Plateau Lake Ecology and Environmental Health, College of Agronomy and Life Sciences, Kunming University, [2]Great Lakes Institute for Environmental Research, University of Windsor. **Identification of antibacterial compounds from *Microcystis* aeruginosa metabolites using machine learning and molecular docking.**

The identification of antibiotics holds profound implications for global public health. Cyanobacterial secondary metabolites have been recognized as promising resources for antibiotics, with a few exhibiting reported antibacterial activity. Yet, the antibacterial potential of secondary metabolites from *Microcystis aeruginosa*, the commonly dominant species in freshwater cyanobacterial blooms worldwide, remains largely unexplored. Previously, we identified 3808 compounds from the intracellular and extracellular metabolites of *M. aeruginosa,* by using widely targeted metabolomics analysis. In this study, we screened the potential antibacterial compounds from them by employing seven machine-learning models and then validated through molecular docking. We identified 23 chemicals, of which 13 had previously been reported to possess antibacterial activity. Among them, tetrapentylammonium and adouetine Y exhibited high binding affinity to antibiotic targets. This research contributes to the expanding knowledge of exploring diverse sources for antibiotic discovery from cyanobacteria.

Hailing Wang, Lin Li and **Xuezhi Zhang**, Institute of Hydrobiology, Chinese Academy of Sciences. **Production and Release of 2-MIB in Pseudanabaena: Effects of Growth Phases on Cell Characteristics and 2-MIB Yield.**

2-methylisoborneol (2-MIB), a secondary metabolite produced by cyanobacteria, often causes the musty odor incident in water, threatening the safety of drinking water supply. This study investigated the effects of growth phases on the production behaviors of 2-MIB by Pseudanabaena. The effects of cell characteristics on the production and release of 2-MIB were explored. The total 2-MIB concentration increased at the exponential phase and decreased at the declining phase, consistent with the changes in cell density. However, the total 2-MIB yield (1.12-1.27 fg cell-1) of Pseudanabaena had no significant difference in the whole growth cycle ($p < 0.05$). Meanwhile, the extracellular 2-MIB yield increased significantly from 0.31 fg cell-1 in the exponential phase to 0.76 fg cell-1 in the declining phase ($p < 0.05$), and the corresponding proportion of extracellular 2-MIB improved noteworthy from 25.13 % to 59.16 % ($p < 0.05$). The surge of extracellular 2-MIB in the declining phase could be attributed to break Pseudanabaena filament, as indicated by the decrease in the Dmean, during cell aging. The findings of this study contribute to a more inclusive comprehension and management of musty odor issues resulting from cyanobacteria in water supply.

Chuyan Zhao[1], Pengfei Xue[1], Dan Titze[2], Chenfu Huang[1] and Miraj Kayastha[1], [1]Michigan Technological University, [2]NOAA. **Improved thermal structure and lake surface temperature simulation for Lake Superior using a data assimilative model.**

Temperature structure is one of the most important fundamental characteristics of a lake, affecting all biological, chemical and physical processes. To better understand the biophysical characteristics of a lake, it is vitally important to get spatial and temporal variations in the thermal structure of the lake. Due to the lack of reliable, long-term, continuous records of measured thermal structure, three-dimensional hydrodynamic models have been widely applied in lakes, but noticeable errors and uncertainty still exist in boundary conditions and forcing terms. In this study, a simple data assimilation strategy was developed and evaluated to improve the hindcast and forecast of the thermal structure and lake surface temperature (LST) in Lake Superior. The results indicated that the DA method improved the hindcast of spatial LST and thermal structures in the adjacent regions of

the assimilated thermistors. Additionally, the study illustrated the assimilation with only satellite-measured LST still improved thermal structure hindcast for the entire lake. This holds particular significance as mooring observations are limited to specific locations, while satellite-derived LST offers a more expansive coverage. Furthermore, the data assimilative model demonstrated its capacity to augment short-term forecasting accuracy, effectively mitigating uncertainties to an acceptable level for both LST and thermal structure. The model achieved a predictive timescale of 1-5 days for lake surface temperature and 1 month for thermal structure forecasting (excluding periods of well-stratification in summer).

Bowen Zhou[1], Chris Parsons[2], Mahyar Shafii[1], Fereidoun Rezanezhad[1], Elodie Passeport[3] and Philippe Van Cappellen[1], [1]University of Waterloo, [2]Environment and Climate Change Canada, [3]University of Toronto. **How efficient are bioretention cells in mitigating urban stormwater phosphorus and nitrogen export?**

Bioretention cells (BRCs) are promoted as a best management practice (BMP) to attenuate nutrient enrichment caused by urban stormwater runoff. We extracted hydrological and phosphorus (P) and nitrogen (N) concentration data for over 400 precipitation events across more than 30 BRCs from the International Stormwater BMP Database. The concentrations of total P (TP) and soluble reactive P (SRP) were on average higher in the surface outflows of BRCs compared to the inflows. Nonetheless, the corresponding outflow loads of TP and SRP were generally lower, mainly because of the reduction of the surface runoff volumes. By contrast, BRCs exhibited on average lower outflow total N (TN) concentrations while dissolved inorganic N (DIN) concentrations were similar between outflow and inflow. Hence, because they are generally more efficient in reducing N than P loads, BRCs tend to decrease the TN:TP and DIN:SRP ratios of stormwater runoff. Changes to P and N speciation were also prevalent, with BRCs typically increasing the SRP:TP and $(NO_3^-+NO_2^-):NH_4^+$ ratios in the surface outflow. By conducting random forest analysis, we identified that the effects of BRCs on the P and N concentrations of urban runoff can be partially accounted for by explanatory variables such as the inflow concentrations. Although the P and N loads in surface runoff are usually reduced by BRCs, the implications for downstream nutrient limitation and potential groundwater quality deterioration deserve further attention.

Xing Zhou[1], Pengfei Xue[2], Mark Rowe[3], Peter Alsip[4], David Bunnell[5], Tomas Höök[6], Edward Rutherford[3], Paris Collingsworth[6] and Spencer Gardner[6], [1]Georgia Institute of Technology, [2]Michigan Technological University, [3]Great Lakes Environmental Research Laboratory, National Oceanic and Atmospheric Administration, [4]Cooperative Institute for Great Lakes Research, University of Michigan, [5]Great Lakes Science Center, U.S. Geological Survey, [6]Purdue University. **Climate Change Impact on Lake Michigan Phytoplankton: A Biophysical Modeling Study.**

Physical factors such as water temperature, water column mixing, and light are crucial for the phytoplankton abundance and primary production in Lake Michigan. The potential impacts of climate change on these factors could significantly affect the dynamics of Lake Michigan's phytoplankton. In this study, we employed an integrated modeling framework to project the impact of climate change. This framework included a two-way coupled 3D lake-ice-climate system (GLARM), a hydrodynamic model (FVCOM), and a nutrient-phytoplankton-zooplankton-detritus (NPZD) model, further enhanced by a compartment representing the invasive quagga mussel (*Dreissena rostriformis bugensis*). Our approach encompassed historical simulations for the period 2005-2014, as well as two sets of future projections for the mid-21st century (2041-2049) and the late 21st century (2091-2099), utilizing the Representative Concentration Pathway (RCP) 8.5 scenario, a 'business as usual' scenario. Our results show water temperature and mixing changes significantly

influence phytoplankton seasonal patterns, affecting the timing and intensity of winter-spring blooms and the depth of the chlorophyll layer. The mid-depth and offshore winter-spring blooms are likely to weaken and delay due to reduced winter stratification and spring turnover. The deep chlorophyll layer may develop 15-30 days earlier in the mid- and late 21st century, with longer duration from extended summer stratification. The model also predicts increased primary production and pattern shifts under projected climate scenarios.

Elizaveta Zvereva[1], Min Liu[1], Ariana Spentzos[2], Heather Whitehead[3], Alyssa Wicks[3], Chunjie Xia[4], Tong Yang[5], Zhanyun Wang[6], Darcy Burns[1], Arlene Blum[2], Graham Peaslee[3], Marta Venier[4], Hui Peng[1] and Miriam L Diamond[1], [1]University of Toronto, [2]Green Science Policy Institute, [3]University of Notre Dame, [4]University of Indiana, [5]McGill University, [6]Empa- Swiss Federal Laboratories for Materials Science and Technology, Technology and Society Laboratory. **Estimating the mass of PFAS in exterior building materials.**

Water and air in urban areas often contain elevated levels of per- and polyfluoroalkyl substances (PFAS), however sources of these levels are poorly known. We investigated exterior building materials as a source of PFAS released into the environment by estimating the mass of PFAS on exterior surfaces of 13 building from Canada and the United States as case studies. We detected fluorine in 55% of paints, sealants and textiles using Particle-Induced Gamma-Ray Spectroscopy (PIGE). Subsequent testing on a subset of samples using ^{19}F-NMR, LC-HRMS, and GC-MS confirmed the presence of PFAS in samples with elevated total fluorine. To estimate the mass of PFAS that could enter the environment from these materials, we classified exterior building surfaces into 5 categories that could be coated in a paint or sealant made with PFAS. We then used the 10th, 50th and 90th percentiles of total F concentrations for product samples with detectable total F measured by PIGE (μmol F/g wet weight). The largest residential house examined, with a floor area of 700 m^2, contained 7, 91 and 342 g of PFAS in coatings on exterior surfaces for the 10th, 50th and 90th percentiles, respectively, of PFAS content in each coating. With over 10,000 single-family homes built in Canada since 2021, exterior building materials may be a significant source of PFAS to surface and ground water.