ABSTRACTS

64th Annual Conference on Great Lakes Research

#iaglr21

Convened by the
International Association for Great Lakes Research
with support from
Michigan Technological University

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 64th Annual Conference on Great Lakes Research, organized by presenter. Presenters are underlined.

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A. Jabbari, University of Guelph; J. Ackerman, University of Guelph, Integrative Biology; L. Boegman, Queen's University, Civil Engineering; Y. Zhao, Ontario Ministry of Natural Resources. **Episodes of extreme winds reduce water quality via upwelling into the western basin of Lake Erie**.

Climate change affects physical and biogeochemical processes in lakes. We show significant increases in surface-water temperature (> 0.2% $year^{-1}$) and wave power (> 1% $year^{-1}$; the transport of wind energy into lake-surface motion) associated with atmospheric phenomena (Atlantic Multidecadal Oscillation and Multivariate ENSO) in August between 1980 and 2018 in the Laurentian Great Lakes. A pattern in wave power, in response to extreme winds, was identified as a proxy to predict interbasin coupling in Lake Erie. This coupling involved the upwelling of cold and hypoxic (DO 2 mg L^{-1}) hypolimnetic water containing high total phosphorus concentration from the seasonally stratified central basin into the normally well-mixed western basin opposite to the eastward flow. Analysis of historical records indicate that hypoxic events due to interbasin exchange have increased in the western basin over the last four decades (43% in the last 10 years). The affects of theses perturbations on water quality has implications for Lake Erie, as well as other large lakes with multiple basins, lake-rivermouth, or interconnected basins of reservoirs.

U. Adhikari, Z. Wang, H. Liao, Z. Curtis, Hydrosimulatics INC; S. Li, Michigan State University. **Adaptive data-enabled hydrological and hydraulic modeling platform for the Great Lakes region**.

Hydrological and hydraulic models are widely used tools for studying environmental flow and transport. These models often have unique input/output data formats, and thus model integration requires significant time and effort. Here, a web-based platform with a user-friendly interface is introduced to deal with geospatial data processing, modeling and visualization. By integrating the Soil Water Assessment Tool (SWAT) and Hydrologic Engineering Center's River Analysis System (HECRAS), geospatial databases can be shared by both models and exchange simulation results between models flawlessly. So, this platform can compute hydrologic and hydraulic dynamics from large watersheds to specific channel flow. Because of the virtually effortless integration, modeling and analysis are instantaneous, and the results can be visualized on the interactive web interface in real time. The model integration method is applied to a watershed in the Great Lakes and results are presented.

H. Ai, J. Sun, K. Zhang, H. Zhang, Case Western Reserve University, Department of Civil and Environmental Engineering. **Predicting algal blooms in Lake Erie by random forest and long short-term memory methods**.

As the most vulnerable lake to anthropogenic activities in the Great Lakes, Lake Erie has recurring harmful algal blooms largely because of phosphorus release from agricultural runoffs in the Maumee River watershed. To develop a robust, comprehensive predictive model for bloom occurrence, parameters including nutrient discharge, wind, solar radiation temperature, precipitation, ice cover, land use and fertilizer usages were considered. Radom forest has been demonstrated to be robust in building predictive models, while long short-term memory is known for its applications in nonlinear time series modeling. Based on the satellite-derived ten-day composite bloom extent values from 2002 to 2019, nutrient, meteorological, and water quality parameters were investigated to build 10-day scaled bloom prediction models by these two methods. Compared to studies focusing on forecasting annual bloom severity, this research will provide a more informative alert system and bloom prediction guide.

S. Alexander, Fisheries and Oceans Canada; J. Provencher, ECCC; D. Henri, Environment and Climate Change Canada; J. Taylor, Carleton University, Canadian Centre for Evidence-Based Conservation; J. Lloren, University of Lethbridge; L. Nanayakkara, Fisheries and Oceans Canada; J.T. Johnson, University of Kansas, Geography & Atmospheric Science; S.J. Cooke, Carleton University, Department of Biology; A. Berberi, Carleton University; M. Ballard, University of Manitoba, Department of Chemistry; N. Klenk, University of Toronto Scarborough, Department of Physical and Environmental Science; C. Song, University of Toronto; D. Littlechild, Carleton University. **Bridging Indigenous and Western sciences in aquatic research, monitoring, and management in Canada**.

While the benefits of incorporating multiple types of knowledge in environmental research and management are many, doing so has remained a challenge. This presentation presents the results from two systematic maps that examined the extent, range, and nature of the published literature that seeks to respectively bridge Indigenous and Western sciences in aquatic research, monitoring, and management in Canada. More than 130 case studies were included collectively between the systematic maps focused on the coastal-marine context and freshwater aquatic ecosystems respectively. The results highlight the diversity of ways knowledge systems can be woven, but that the application of these approaches are limited to some key regions and species. Further inquiry focused on the level and quality of Indigenous participation in collaborative research provides key insights for creating and maintaining an ethical space of engagement for research and monitoring.

B. Alipour Parvizan, Clarkson University; S. Fernando, Clarkson University, Center for Air Resources Engineering and Science; B. Crimmins, T. Holsen, Clarkson University, Civil and Environmental Engineering. **Concentration and Temporal trend of HBCDD in fish tissues from the Great Lakes using UPLC-HRMS**.

Hexaboromocyclododecane (HBCDD) is a brominated flame retardant (BFR) that is commonly used as part of building insulation and in many common household items. The global production volume of this BFR reported to be 600,000 tons per year in 2001. Due to the toxic and persistent nature of this compound multiple regulatory agencies have started to monitor there levels in the environment and food. Therefore, as a part of Great Lakes Fish Monitoring and Surveillance Program (GLFMSP), an analytical method for measuring the concentration of three HBCDD isomers in fish tissues has been developed. Different extraction techniques were evaluated prior to analysis of the samples using liquid chromatography coupled to high resolution mass spectroscopy (UPLC-HRMS). Using the optimized method, the concentration and temporal trend of HBCDD have been established.

K. Almack, Ontario Ministry of Natural Resources and Forestry; R. Lauzon, Chippewas of Nawash Unceded First Nation, Fisheries Assessment Program; E.S. Dunlop, ON Ministry of Natural

Resources, Trent University; A. Duncan, Chippewas of Nawash Fishery Assessment. **Using the Two-Eyed Seeing Approach" to Resolve Conflict and Build Trust: A SON/OMNRF Case Study"**.

The Saugeen Ojibway Nation (SON) and the Ontario Ministry of Natural Resources and Forestry (OMNRF) collaboratively govern the commercial fishery in the SON's traditional territory of Lake Huron and Georgian Bay The relationship can be characterized as conflict (pre 2000), transition to joint-governance (2000-2018) and, most recently, a new era of two-eyed seeing (2018-present). In the transition era, relying on technical specialists and external facilitators led to mistrust and created conflicts regarding legitimacy and implementation. In this presentation, we will share how we are building a relationship of trust and co-learning through the "Two-Eyed Seeing Approach." We will present our ethical knowledge co-production framework outlining the principles we follow including the importance of leadership and self-awareness, ethical space and equity in decision making, process design and facilitation, building capacity through multi-level efforts and the importance of community involvement. We hope that this will serve as a helpful case study for both Indigenous communities and resource managers navigating fishery related conflicts.

K. Almack, Ontario Ministry of Natural Resources and Forestry; A.T. Duncan, Chippewas of Nawash Unceded First Nation #27, Fisheries; A.J. Reid, University of British Columbia, Institute for the Oceans and Fisheries; N.W. Boucher, Great Lakes Fishery Commission, Science Program. **Panel on Wise Practices in Co-developing Knowledge with Indigenous Communities (75 min)**.

The term best practices implies a singular path to success, while wise practices are contextually grounded and enacted by thoughtful and sensitive practitioners. In this panel discussion, panelists will share their experiences and wise practices in co-developing projects with local communities while upholding Indigenous governance and sovereignty. Panelists will speak to a diversity of experience co-learning with Indigenous communities, academic institutions and government agencies. These reflections on wise practice will serve as lessons on how to equitably and ethically apply Indigenous ecological knowledge to balance and support sustainable management of Great Lakes ecosystems.

L. Almeida, Ohio State University, Aquatic Ecology Laboratory; S.A. Ludsin, Aquatic Ecology Lab, The Ohio State University; E. Marschall, The Ohio State University, Aquatic Ecology Lab. **Maternal experience and recent growth influence growth rate in Lake Erie Walleye**.

The ways in which previous and recent environments influence growth can be difficult to disentangle. We examined which combinations of the following pathways affected annual growth of 3-5 year old Lake Erie Walleye cohorts during 1978-2015: P1) recent environmental conditions; P2) traits of the cohort in the previous year; P3) early-life cohort density; P4) early-life size; and P5) conditions experienced by parents. Our results from model selection using piecewise SEM indicated that cohort-specific growth in Lake Erie Walleye was most related to P2 and P5. The negative relationship to growth in the previous year (std. est.=-0.32, P 0.001) indicate that Walleye may exhibit compensatory growth. The positive effect of percent ice prior to hatching (std. est.=0.14, P=0.029) demonstrates that warm winters influence offspring for many years. Understanding the effects of environmental conditions experienced through life will help inform our understanding of responses to environmental change.

K.M. Alofs, University of Michigan, School of Environment and Sustainability; P. Siciliano, University of Michigan, School for Environment and Sustainability; J. Read, University of Michigan Water Center; P. Seelbach, University of Michigan, School for Environment and Sustainability. **Online case studies for teaching science and management in the Laurentian Great Lakes**.

In collaboration with students and practitioners, we have developed a series of case studies which illustrate current management challenges for the Laurentian Great Lakes Region. Our cases are available on Gala, an online platform which includes multimedia edgenotes, classroom exercises, and teaching guides. The platform is open-access and welcomes and facilitates new case development. Our six cases focus on invasive species control, nutrient management, restoring areas of concern, lake level policy, promoting the resilience of threatened species, and treaty rights and fisheries management. These cases highlight the challenges of sustainably managing regional-scale socio-ecological systems and engage students in applying scientific knowledge to real-world challenges. We share this online curriculum, focused on complex issues in the Great Lakes, for case-based learning both in classrooms and beyond.

P.J. Alsip, University of Michigan, Cooperative Institute for Great Lakes Research; M.D. Rowe, NOAA GLERL; J. Smith, Cooperative Institute for Great Lakes Research; E.J. Anderson, NOAA, Great Lakes Environmental Research Laboratory. **An Experimental Biophysical Forecast System to Support Lake Michigan CSMI 2020**.

Understanding how tributaries influence nutrient transport and productivity patterns in Lake Michigan was a goal of the 2015 and 2020 Cooperative Science and Monitoring Initiative (CSMI). NOAA GLERL and CIGLR developed an experimental biophysical forecast model to help field researchers target productivity hotspots and river plumes. 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 40 rivers. We evaluated real-time model performance primarily by comparison to satellite-derived chlorophyll and dissolved organic carbon. The model simulated spatial and temporal patterns in chlorophyll and dissolved organic carbon associated with coastal upwelling/downwelling and tributary inputs. We will present examples of the biophysical forecast, comparisons to satellite data, and web products designed to support field researchers.

B. Alsip, US EPA, Great Lakes National Program Office; P. McKinney, ORISE, US EPA Office of Research and Development, CCTE/GLTED; T. Hollenhorst, S. Miller, J.C. Hoffman, US EPA, Great Lakes Toxicology and Ecology Division. **Deep dives in Lake Erie: flying a glider in the shallowest Great Lake**.

This poster presentation will address lessons learned from the 22-day deployment of a Teledyne Marine Slocum glider by the U.S. Environmental Protection Agency in Lake Erie in 2019. Autonomous Underwater Vehicles (AUVs), including gliders, can complement ship-based observations by adding broader spatial and temporal context. This study primarily focused on the spatial extent of the recurring hypoxic zone in part of the lake's central basin, which required the glider to routinely fly within 1 - 2 m off bottom. Adapting flight for Lake Erie requires modifications to standard programming, maintenance, and calibration protocols, which have been primarily developed for oceanographic research. The glider regularly passed near two stationary dissolved oxygen sensors on buoys for data comparison and validation. We observed the recurring hypoxic zone demonstrating the ability for autonomous gliders to successfully operate in close proximity to the bottom of a lake.

A. Ames, B. Saltzman, M. Valigosky, University of Toledo, Population Health; D. Dwyer, University of Toledo, Environmental Sciences; K.P. Czajkowski, University of Toledo, Geography & Planning. **HAB associated health effects and airborne microcystin levels among recreational lake users**.

The association between potential microcystin exposure and self-reported health symptoms for shoreline residents and recreational users of the western basin of Lake Erie was investigated in

2018 and 2019. In addition, lake-derived, airborne microcystin levels were evaluated in 2019. Data for exposure frequency, duration, activity, and location and for dermal, respiratory, and GI issues were collected via an online survey. Samples of lake water and air were collected and analyzed for algal taxonomy (water samples only) and microcystin concentrations. In 2019, respiratory symptoms were 5 times more likely for those engaging in shoreline activities and 3 times more likely for motorized boating activities. Microcystin was detected in the air at low levels when the bloom was at its peak. Findings from this study support the issuance of public health advisories and suggest additional targeted messaging should be explored.

O.C. Anderson, Central Michigan University, Department of Biology; D.G. Uzarski, Central Michigan University, Institute of Great Lakes Research, CMUBS, and Department of Biology; A.M. Harrison, A. Kneisel, Central Michigan University, Institute for Great Lakes Research. **The influence of extreme water levels on coastal wetland extent across the Laurentian Great Lakes**.

Great Lakes Coastal Wetlands (GLCWs) host many ecosystem services that rely on plant communities that are hydrologically dependent on Great Lakes water levels. Hydrologic regimes of the Great Lakes are shifting: 2000–2015 marked extended low period and record highs were reached in 2017–2020. Wetland locations adjust to lake level increases if barriers are absent, allowing for migration. Since there is a lag-period between changes in water levels and migration, water levels could change faster than wetlands can migrate. Recent Coastal Wetland Monitoring Program (CWMP) field observations suggest various wetlands have moved closer to shore or shrunken. Our objective is to better understand how shifts in water levels impact GLCW extent. We quantified wetland extent and distance-to-shore from 2011–2019 using CWMP data and satellite imagery. By relating wetland extent and distance-to-shore to water levels, we show how wetlands vary in response to an inundation gradient. A better understanding of how GLCWs change with extreme shifts in water levels will provide insight on how altered Great Lakes hydrology impacts GLCW ecosystem services.

H. Anderson, T.H. Johengen, R. Miller, University of Michigan, Cooperative Institute for Great Lakes Research (CIGLR); C.M. Godwin, University of Michigan, Cooperative Institute for Great Lakes Research. **Accelerated release of phosphorus from sediments in Lake Erie's central basin is a symptom of anoxia, not hypoxia**.

One of the biggest threats to Lake Erie is eutrophication, sped up in recent years by human activity in the watershed. Internal phosphorus (P) loading from sediment is a potential positive feedback to this problem. This research aims to quantify internal P loading in Lake Erie's central basin as a function of depositional environment and season. We used controlled replicated sediment core experiments to estimate internal P flux under varying oxygen and temperature conditions and compared these results with a parallel in situ P sensor. Our research shows that oxic P release is slow relative to anoxic P flux which begins within 24 hours of anoxia and ranges from 5.18 – 30.7 mg m^{-2} day^{-1}. Both oxic and anoxic flux rates were similar across seasons and temperatures (8-14°C) and timing of anoxic flux onset was earliest in fall. Understanding the effects of environmental conditions on internal P loading allows us to estimate total basin loading and its implications for P budget management.

E.J. Anderson, NOAA, Great Lakes Environmental Research Laboratory; A. Fujisaki-Manome, CIGLR, University of Michigan; J. Kessler, NOAA, Great Lakes Environmental Research Laboratory; A.J. VanderWoude, NOAA - GLERL; P. Chu, NOAA, Great Lakes Environmental Research Laboratory. **WITHDRAWN: Evaluation of modeled ice thickness using satellite-based ice type classification (ICECON)**.

Ice conditions in the Great Lakes are critical to commercial navigation and Coast Guard ice breaking operations. The next-generation NOAA Great Lakes Operational Forecast System (GLOFS) includes real-time ice forecast guidance for ice concentration, thickness, and velocity. The next-gen GLOFS is based on the FVCOM and CICE models. While evaluation of modeled ice concentration has been carried out using daily ice analyses from the US and Canadian Ice Centers, ice thickness validation is limited due to sparse ice thickness data. Recently, the US National Ice Center and Great Lakes CoastWatch introduced an Ice Condition (ICECON) or type classification product that uses synthetic aperture radar (SAR) to provide frequent gridded data on Great Lakes ice types and inferred thickness. In this study, we use the ICECON product to evaluate modeled ice thickness from the next-generation GLOFS and investigate options for model improvement.

T.D. Androschuk, N. Hermawan, University of Toronto Scarborough, Department of Physical and Environmental Sciences; N.E. Mandrak, University of Toronto Scarborough, Department of Biological Sciences. **Freshwater biodiversity is under-represented in protected areas in Canada, including the Great Lakes basin**.

Protected areas (PAs) are one of the most commonly used strategies to protect biodiversity. Canada committed to protecting 17% of its terrestrial land & inland waters by 2020 & 30% by 2030. Little research has focused on potential post hoc protection of fresh waters & freshwater biodiversity by existing PAs. Our objective was to determine the representativeness of freshwater biodiversity in existing Pas in Canada. As there is a lack of detailed freshwater biodiversity data for Canada, the proportions of fresh waters and broad-scale freshwater biodiversity & stress indices in PAs were determined nationally & for each freshwater biogeographic zone. Fresh waters & freshwater biodiversity is underrepresented in PAs. Approximately 6% of waterbodies are found in PAs. Representativeness was generally lower in southern Canada. Fresh waters with high stress levels were under-represented inside PAs. In the Great Lakes zone, less than 3% of fresh waterbodies are found in PAs. Representation of freshwater biodiversity in PAs needs to be increased, focusing on establishing representation on areas where little or none exists.

G. Ankley, USEPA/ORD. **Pathway-Based Approaches for Assessing Biological Hazards of Complex Mixtures of Contaminants in the Great Lakes**.

Great Lakes watersheds can potentially be impacted by a complex mixture of contaminants, only a fraction of which are known and can be detected analytically. And many contaminants that can be measured have little or no data concerning their potential toxicity. To address these challenges requires a multidisciplinary combination of targeted and nontargeted analytical and biological monitoring techniques and computational methods/databases. These tools include state-of-the-art instrumental analyses, multi-endpoint *in vitro* and *in vivo* bioeffects assays that can be employed in a rapid, cost-effective manner, and bioinformatic approaches that enable the use of novel sources of data to assess potential toxicity. Scientists at the Duluth, MN USEPA lab have for the last decade been involved in efforts supported through the Great Lakes Restoration Initiative to develop and demonstrate the utility of these types of tools. This talk will provide an overview of this work, as well as examples of its application at Great Lakes Areas of Concern. *This abstract does not necessarily reflect the opinions of the USEPA.*

G.M. Annis, The Nature Conservancy, Conservation Science; M. Herbert, The Nature Conservancy; S. Hickel, The Nature Conservancy, Conservation Science; P. Kohn, The Nature Conservancy; E. Rutherford, NOAA Great Lakes Environmental Research Laboratory; D.B. Bunnell, USGS Great Lakes Science Center, Great Lakes Science Center; N.W. Boucher, Great Lakes Fishery Commission, Science Program; Y. Kao, A. Honsey, USGS Great Lakes Science Center; A. Verdeja,

The Nature Conservancy; J. Ross, Michigan State University; D. Forsyth Kilijanczyk, Michigan DNR. **Mapping priority spawning and nursery habitat for cisco and lake whitefish**.

Many native species of Great Lakes fishes are experiencing reduced population numbers in part from the loss or degradation of important spawning habitats. Datasets of historic spawning locations offer the potential to inform models that can help identify other locations with similar habitats throughout the Great Lakes thus providing a better understanding of where spawning may still be occurring or places in need of restoration. The Atlas of the Spawning and Nursery Areas of Great Lakes Fishes, often referred to as the Goodyear Spawning Atlas, provides a wealth of historic data but is often criticized for being spatially imprecise. We worked to refine the spatial accuracy of the Goodyear data for two species, cisco and lake whitefish, and used the improved data to generate Maxent models informed by ten habitat layers for the entire Great Lakes. We believe that the resulting models will help guide cisco and lake whitefish management and restoration efforts across the Great Lakes.

D. Apps, U.S. Army Corps of Engineers - Detroit District, Office of Great Lakes Hydraulics and Hydrology; K. Walker, U.S. Army Corps of Engineers - Detroit District, Emergency Management Office; L.M. Fry, NOAA, Great Lakes Environmental Research Laboratory. **Comparison of Events that Led to the 1980s and Recent High-Water Periods and the Impacts to Shoreline Communities**.

The Great Lakes have experienced record high water levels in 2019 and 2020, with most of the monthly record highs surpassing previous records that occurred between 1985 and 1987. Since the record high lake levels of the mid to late 1980s, water levels have fluctuated near average until the late 1990s when Lakes Superior and Michigan-Huron entered an extended period of record low water levels that lasted through early 2013. However, beginning in 2013 water levels began to rebound and since then, continued to rise toward the record high levels of 2019 and 2020. Both periods of record high water levels were a result of several consecutive years of wet conditions in the region that pushed water levels upward. Consequently, shoreline communities were faced with challenges due to the high water and strong storms that moved across the region causing coastal flooding and erosion. This presentation will compare the meteorological events and conditions that led to each period of extremely high lake levels and how communities responded to the challenges associated with these high-water events.

J. Apriesnig, Michigan Technological University, College of Business; T. Warziniack, USDA FS; D. Finnoff, University of Wyoming; H. Zhang, Eureka Aquatic Research, LLC.; K. Lee, University of idaho; D.M. Mason, E. Rutherford, NOAA Great Lakes Environmental Research Laboratory. **THE CONSEQUENCES OF MISREPRESENTING FEEDBACKS IN COUPLED HUMAN AND ENVIRONMENTAL MODELS**.

We present a framework that couples a regionally specified economic model with an Ecopath with Ecosim food web model and includes bidirectional feedbacks between the two systems. We simulate the bioeconomic impacts of a potential Asian carp invasion of Lake Erie's food web and regional economy with and without bidirectional feedbacks between the economy and the ecosystem. When feedbacks are omitted there are large ecological variations in projected populations of many target species, with differences in population levels of up to 80 percentage points. We find that the magnitude of the difference in biomass projections increases as a species' fishing-effort intensity of recreationally targeted species increases. Results demonstrate the need to model bidirectional feedbacks between the economy and the ecosystem to forecast both economic and ecological impacts; omission of these feedbacks in this case may appear to be economically trivial yet have large ecological consequences.

J.K. Atalitsa, Kenya Marine and Fisheries Research Inst., Turkana Station, Limnology; J. Malala, Kenya Marine and Fisheries Research Institute, Turkana Station, Fisheries Department; C. Olilo, M. Obiero, C. Bironga, KENYA MARINE AND FISHERIES RESEARCH INSTITUTE, Fisheries; K.O. Obiero, KENYA MARINE AND FISHERIES RESEARCH INSTITUTE, Research. **Lake Turkana trophic structure as a basis for ecosystem approach to fisheries management**.

Over the past four decades, there have been attempts to expand the fishery of Lake Turkana without much success. This has been attributed to long food chains leading to low yields of commercially viable fishes. To understand the trophic structure of the lake, two surveys were undertaken for this study. A total of 900 fish representing 13 species belonging to 11 families were analyzed. The sampled species were dominated by *Tilapia sp* (19%), *Hydrocynus forskalii* (16.9%), *Schilbe uranoscopus* (16.9%) and *Synodontis sp.* (16.2%). *Microcystis sp* (Cyanophyceae) accounted for 90% of food items for *O. niloticus*. A mixture of detritus, crashed ostracod shells, sand particles, plant tissues and mud were consumed by *L. horie*. *Lates sp.* preyed upon insects and fish species particularly *H. forskalii*, *Alestes sp* and *O. niloticus* while *H. forskalii* preyed on fish and insects (corixids). The study concludes that *H. forskalii*, *Synodontis sp.*, *Lates sp.*, *Tilapia sp.* and *L. horie* are the most dominant fish in Lake Turkana with each fish species having adopted its own feeding niche. Fishermen are advised to target these species for commercial exploitation.

J.A. Austin, University of Minnesota, Duluth, Large Lakes Observatory; T. Hrabik, University of Minnesota-Duluth, Department of Biology; D. Branstrator, UM Duluth, Department of Biology. **An abrupt decline in springtime zooplankton diel vertical migration due to a shift in stratification regime**.

Returned signal strength intensity measurements from an acoustic Doppler current profiler deployed at an open-water site in Lake Superior from May-July 2019 are used to estimate the scattering intensity over the top 50m of the water column. It displayed a strong diel signal, with higher scattering intensity at night, consistent with the normal diel vertical migration of planktonic organisms. However, the intensity of the nocturnal scattering signal decreased abruptly on 10 June, coincident with the end of winter stratification (cold water on top of warmer water) and the beginning of the neutrally stratified period. We hypothesize that the sudden change in zooplankton behavior is due the availability of phytoplankton deep in the water column after the transition, made possible by radiatively driven convection mixing the entire water column on very short time scales.

B

E. Bagosy, Central Michigan University, Biology & Institute for Great Lakes Reseach; H.J. Carrick, Central Michigan University, Biology & Institute for Great Lakes Research; H.A. Vanderploeg, NOAA GLERL. **Seasonal occurrence and production of potentially harmful algal blooms in western Lake Erie**.

The presence of cyanobacterial harmful algal blooms (cyano-HABs) in the western basin of Lake Erie is an unexpected occurrence, given the improvements in water quality there. In this study, we aimed to identify if shifts have taken place in the plankton assemblage that coincides with the increase in cyano-HABs. Monthly samples were collected in the western basin of Lake Erie during the May-October period at key in-lake stations, from which taxonomic composition (cell counts) and primary production rates (14-carbon uptake) were measured. Our initial findings indicate that Microcystis blooms in the western basin of Lake Erie were the result of low (but sustained) primary production rates, along with seasonal declines in production by pico- and nanoplankton components of the assemblage. The distinct seasonal pattern for phytoplankton in western basin of Lake Erie, differs from that typical to other regions in the Great Lakes.

J.T. Ives, University of Windsor, Great Lakes Institute for Environmental Research; D. Banda, Lilongwe University of Agriculture and Natural Resources. **Effectiveness of solar tent dryer on drying time, microbial and fat quality of fishes, Lake Malawi**.

Fresh and parboiled *E. sardella* and fresh *Copadichromis inornatus* fish samples were dried using a solar tent dryer (STD) prototype and open sun dryer (OSD). A case study was also conducted to assess the perception of small-scale fish processors on STD performance. OSD fishes attained the targeted moisture level of 15% faster than the STD fishes, suggesting that high humidity levels in STD influenced the drying process by limiting the amount of moisture the air could absorb. Higher fungal and bacterial levels were identified in OSD than STD fish samples. Higher levels of PV on open sun-dried samples were as a result of direct exposure of oxygen and sunlight which induced lipid oxidation. Small-scale fish processors felt STDs produce high quality fish products with longer shelf life but challenges include drying delays and human health effects. In conclusion, the STDs prototype is ideal for fish processing, but performance in terms of drying time and air circulation should be improved.

C.M. Bangkong, K.M. Chomiak, Rochester Institute of Technology, Thomas H. Gosnell School of Life Sciences; J.M. Daily, Rochester Institute of Technology, School of Mathematical Sciences; S.W. Day, Rochester Institute of Technology, Kate Gleason College of Engineering; N. Eddingsaas, Rochester Institute of Technology, School of Chemistry and Materials Science; M.J. Hoffman, Rochester Institute of Technology, School of Mathematical Sciences; A. Hudson, C. Tyler, N. Wong, Rochester Institute of Technology, Thomas H. Gosnell School of Life Sciences. **Molecular identification of antibiotic resistant plastic-associated freshwater bacteria**.

The frequent co-occurrence of plastic debris in aquatic ecosystems and effluent containing antibiotics may result in genomic shifts that lead to antibiotic resistance. Given the variety of plastic polymers and the range of contaminated ecosystems, we need to assess polymer-environment interactions driving microbial characteristics of plastic biofilms. We incubated six plastic polymers for four months in two distinct aquatic environments in Western New York State. Using standard isolation and molecular identification techniques, we sequenced the hypervariable V3-V4 regions of the 16S rRNA gene to identify isolated bacteria using BLAST analysis. These findings will illustrate whether plastic type or environment influences the development of antibiotic-resistant bacteria and provide insight into the potential human health risks of plastic pollution.

J. Barker, University of Windsor, Great Lakes Institute for Environmental Research; G.D. Haffner, Great Lakes Institute for Environmental Research University of Windsor. **Golden mussel overwinter survival at northern invasion front implies high latitude distribution**.

Golden mussel *Limnoperna fortunei* is an invasive bivalve in many freshwater ecosystems. Cold winter temperatures are predicted to restrict its spread to high latitude areas but remains largely untested. We aim to investigate the cold tolerance of golden mussels and to model their potential distribution at higher latitudes. We investigated the overwintering survival of golden mussels using field studies at their northern invasion front, laboratory tests of the lowest water temperature at which mussel filter-feed and modeled their potential global distribution by Maximum Entropy using the updated occurrence records. Golden mussels at the northern invasion front survived for 108 days at temperatures below 5°C and began to filtering at 5.5°C Modeling illustrated a potential distribution of golden mussels at a higher latitude than presently found, including near the lower Laurentian Great Lakes. Our findings suggest enhanced cold tolerance of golden mussels and wider potential distribution.

M.A. Barnard, University of North Carolina, Chapel Hill Inst. of Marine Sci., Institute of Marine Sciences; J.D. Chaffin, Stone Laboratory, Ohio State University; H.E. Plaas, University of North

Carolina, Chapel Hill Inst. of Marine Sci., Institute of Marine Sciences; G.L. Boyer, B. Wei, SUNY, ESF; S. Wilhelm, University of Tennessee, Dept. of Microbiology; K. Rossignol, J. Braddy, University of North Carolina, Chapel Hill Inst. of Marine Sci., Institute of Marine Sciences; G.S. Bullerjahn, Bowling Green State University, Department of Biological Sciences; T. Bridgeman, University of Toledo, Lake Erie Center & Dept. of Environmental Sci.; T.W. Davis, Bowling Green State University, Biological Sciences; J. Wei, M. Bu, Hohai University; H.W. Paerl, University of North Carolina, Chapel Hill Inst. of Marine Sci. **Nutrient limitation dynamics of Western Lake Erie CyanoHAB biomass, microcystin, and anatoxin production**.

Cyanobacterial harmful algal bloom (CyanoHAB) proliferation is a global problem impacting ecosystem and human health. Western Lake Erie (WLE) typically endures two highly toxic CyanoHABs during summer: a *Microcystis* bloom in Maumee Bay extending across the western basin and a *Planktothrix* bloom in Sandusky Bay. To lessen the severity of the WLE blooms, USA and Canada agreed to a 40% phosphorus (P) load reduction. To investigate P and nitrogen (N) limitation of biomass and cyanotoxin production in WLE, we conducted *in situ* nutrient addition and 40% dilution microcosm bioassays in 2019. During the June Sandusky Bay bloom, biomass production and hepatotoxic microcystin and neurotoxic anatoxin production were N and P co-limited with microcystin production becoming nutrient deplete under 40% dilution. During August, the Maumee Bay bloom produced microcystins under nutrient repletion with slight induced P limitation under 40% dilutions, and the Sandusky Bay bloom produced anatoxin under N limitation in both dilution treatments. The results demonstrate that to properly combat cyanotoxin production in WLE, both N and P reduction efforts should be implemented.

S.L. Bartlett, NEW Water Green Bay Metropolitan Sewerage District, Green Bay Metro Sewerage Distr.; E. Houghton, NEW Water Green Bay Metropolitan Sewerage District, Watershed Department; J. Kennedy, NEW Water Green Bay Metropolitan Sewerage District. **Shifting temperature and dissolved oxygen patterns over a multi-decade analysis in Green Bay, Lake Michigan**.

Despite efforts to improve water quality, the Bay of Green Bay is not immune to climatic influences and surface water temperatures are shifting. NEW Water has a well-established monitoring program in lower Green Bay, a eutrophic embayment in Lake Michigan, with vertical profile data records going back two decades. Seasonal surface water temperatures e.g. samples collected June - September on a weekly or biweekly frequency, were significantly warmer (p 0.05) at 5 of the 7 transect sites, moving in a north trajectory. Increased surface water temperatures can potentially impact periods of low dissolved oxygen or hypoxia. Measuring dissolved oxygen and sampling days that were hypoxic is more elusive from vertical profiles on a weekly sampling scheme, however, analyzing continuous monitoring data over three decades from a single station revealed the highest number of hypoxic days were measured in 2019 (38 days), with the previous record of 31 days recorded in 2011.

J. Bartolotta, S. Hardy, Ohio Sea Grant; S. Bixler, Stone Laboratory. **Skip the Straw, Ban the Bag: Does it really work?**

Have you ever wondered if the skipping and banning of single-use plastic items really works? Ohio Sea Grant and Stone Laboratory are working on several projects with Ohio businesses and consumers to Skip the Straw or Ban the Bag. In working with these businesses, project staff have gained insight into the staff and customer response to plastic reduction initiatives. Customer observation, surveys, focus groups, interviews, and financial analyses have all been used to determine what happens to a business when they make the decision to phase out plastics, educate their staff and customers, and establish a pro-environmental business model. In short we can tell you

businesses continue to succeed when straws and bags are no longer freely available, and we have the data to prove it.

A. Bartos, University of Michigan, Michigan Sea Grant; R. Sturtevant, Michigan State University, Michigan Sea Grant; E. Rutherford, NOAA Great Lakes Environmental Research Laboratory; C. Riseng, University of Michigan, School for Environment and Sustainability; D.M. Mason, NOAA Great Lakes Environmental Research Laboratory. **Estimating habitat occupation and preference of Great Lakes invasive fish using GLAHF and GLANSIS**.

At least 39 nonindigenous fish species (NFS) have invaded the Great Lakes. Even though the Great Lakes are a connected system, many unique aquatic ecological units (AEUs) exist within them, allowing for a diverse set of species with a variety of environmental requirements to inhabit the waters. Using the 77 AEUs defined by Great Lakes Aquatic Habitat Framework (GLAHF) and NFS records from GLANSIS, we determined the spatial and ecological extent to which these NFS have spread throughout the lakes. The preferred habitat based on depth, thermal regime, mechanical energy, and tributary influence was identified for each species and trends among taxa were assessed. On average, an AEU had 8.2 +/- 6.0 fish species with a maximum of 24 found in the coastal margin with a high amount of cumulative degree-days, low mechanical energy, and high tributary influence. These results indicate potential future habitat for NFS and inform efforts to prevent and track their spread in the Great Lakes.

A.A. Beecher, University of Toledo, Lake Erie Center, Dept of Earth and Environmental Sciences; T. Bridgeman, University of Toledo, Lake Erie Center & Dept. of Environmental Sci.; G.J. Doucette, NOAA; J. Westrick, Wayne State University, Lumigen Instrument Center; T.W. Davis, Bowling Green State University, Biological Sciences. **Summer Timeline of Microcystin Production in Western Lake Erie using Solid Phase Adsorption Toxin Tracking (SPATT)**.

The array of toxins and toxin concentrations produced by cyanobacteria in lakes may change on time scales that are too short to be adequately characterized by typical weekly water sampling programs. Here we explored the use of Solid Phase Adsorption Toxin Tracking (SPATT) to provide a continuous profile of toxin production. SPATT devices contain a porous resin that passively adsorbs dissolved organic compounds including cyanobacterial toxins over days or weeks with the potential to detect short-lived spikes in toxin levels, and unusual toxins and congeners. In this study we deployed SPATT bags at three locations in Lake Erie's Western Basin for durations of one and two weeks from June to October in 2019 and 2020. For comparison, grab samples for measuring microcystin concentrations via ELISA and samples for qPCR analysis were collected at each site weekly during summer 2020. Here we compare mass spectrometry data for SPATT with ELISA and qPCR results from the summer of 2020.

S.L. Belontz, P.L. Corcoran, University of Western Ontario, Earth Sciences; J. de Haan-Ward, University of Western Ontario, Statistical and Actuarial Sciences; P. Helm, Ontario Ministry of the Environment, Conservation and Parks, Environmental Monitoring & Reporting Branch. **Linking tributary inputs and anthropogenic factors to greater microplastic abundances in sediments of Lake Huron.**

To date, microplastics (MPs; 3 density separation solution of Sodium Polytungstate. Particles were visually examined using a stereomicroscope and randomly selected for Fourier Transform Infrared Analysis. Normalized MP abundances ranged from 59 to 335,714 particles per kg of dry weight sediment (p kg^{-1} dw). Analysis suggests 61% of the variation in MP abundance could be explained by tributary inputs ($p=0.001532$). Additionally, nearby anthropogenic influences such as wastewater treatment plants discharging sewage into the St. Mary's River, and freshwater caged aquaculture sites, could be contributing to higher MP concentrations in the North Channel (47,398

p kg^{-1}). By understanding lake-wide source to sink relationships we can better assess long-term sediment quality trends and priorities.

J.R. Bence, T.O. Brenden, Michigan State University, Department of Fisheries and Wildlife.
Accounting for movement among populations in stock assessment and fishery managment.

Fisheries often exploit fish spawned from several locations within a large system, such as a Great Lake. Two alternative conceptual models view fish stocks as (a) linked meta-populations with ongoing mixing among constituent populations or mixed stocks from distinct populations that mix only during non-reproductive periods. Simulations have been done to provide guidance on how to assess and manage such fisheries, although offered guidance is not always clear to which type of movement it applies. We have conducted simulations exploring the performance of different assessment approaches under several productivity, mixing, and harvest levels. Simulations have been based on life histories and dynamics for species such as Walleye, Lake Trout, and Lake Whitefish. We have found that incorrectly modeling mixed stocks as distinct populations can lead to large biases in estimated abundance and mortality, whereas for some purposes modeling several mixing populations as a single stock is a viable approach. We will summarize these results and contrast them with literature results making different assumptions about population mixing.

L. Berthot, A. St-Hilaire, Institut National de la Recherche Scientifique, Centre Eau Terre Environnement; D. Caissie, Fisheries and Oceans Canada; N. El-Jabi, Université de Moncton.
Inclusion of wetted perimeter in environmental flow analysis in Southern Québec rivers.

Faced with increasing demands for water withdrawals, the Quebec Department of Environment and Fight Against Climate Change is revisiting its guidelines, which advocate the use of 7Q2 and 7Q10, as the environmental flow (e-flow) in rivers over seven consecutive days with a return period of two and ten years respectively. A first study recommended the use of regionally adapted e-flow metrics in Southern Quebec (Berthot et al. 2020). This second study proposed the wetted perimeter as a tool to assess e-flow taking into account aquatic habitat. The maximum curvature method (QMC) was applied and its associated wetted perimeter used as a riverine ecosystems protective threshold. The Tennant method (1976) was computed for poor (10%MAF) to fair (25%MAF; 30%MAF) flow thresholds. A sample of 43 sites for 35 rivers highlighted that the 7Q10 and the QMC flow values were deemed weak (10%MAF) while the 25%MAF, 30%MAF and the summer flow metrics offer enough protection to riverine ecosystems.

M.G. Bezold, K. Gomez, J. Davidson, J.A. Myers, S.M. Collins, Wright State University, Department of Earth and Environmental Sciences; S. Fondriest, Fondriest Environmental, Inc.; S.E. Newell, Wright State University, Department of Earth and Environmental Sciences; M.J. McCarthy, Wright State University, Department of Earth and Environmental Sci. **Sediment microbial nitrogen dynamics in an agricultural settling pond**.

Constructed wetlands are useful for reducing anthropogenic nutrient loading and are often paired with settling ponds, but whether these ponds are a net nitrogen (N) sink, and which N removal pathways are active, remains uncertain. Sampling is often limited to warm months, making pond dynamics during colder seasons a major knowledge gap. We examined sediment N dynamics from Oct 2019-Oct 2020 in an agricultural settling pond connected to a constructed wetland in Ohio. Intact sediment cores were amended with ^{15}N for continuous flow incubations to measure denitrification and N fixation rates. Denitrification was stimulated when ^{15}N-nitrate was added, suggesting substrate limitation. Denitrification rates increased in warmer months, and N fixation occurring simultaneously exceeded denitrification rates, suggesting that pond sediments were a net N source over the sampling period. These results offer new insights into improving agricultural nutrient control practices on a year-round basis.

S.R. Bickman, LightDeck Diagnostics; T.W. Davis, Bowling Green State University, Biological Sciences; C. Petrou, LightDeck Diagnostics; G.L. Boyer, SUNY-ESF; B. Macdonald, M. Lochhead, LightDeck Diagnostics. **Rapid, portable, multiplexed detection of harmful algal toxins in the Great Lakes**.

Harmful algal blooms are a significant threat to fresh waters necessitating routine testing to protect humans from exposure to contaminated drinking and recreational waters and for forecasting and modeling. Since toxin profiles change spatially and temporally there is significant need for rapid tests that can provide real-time, local answers. Currently, the four toxin classes that are typically monitored in freshwater are microcystins (MC), cylindrospermopsins (CYN), saxitoxins (STX) and anatoxin-a (ATX-a). There is currently no method of measuring STX in freshwaters in the field and only a semi-quantitative test strip for ATX-a. A rapid, portable multiplexed test would reduce the time and cost associated with collecting critical data while improving human safety by ensuring that all four toxins are always monitored. The LightDeck technology enables portable, multiplexed detection of toxins and has been demonstrated in a duplex MC/CYN panel and is being expanded to include STX and ATX.

B.A. Biddanda, I.A. Stone, T. Weinke, Grand Valley State University, Annis Water Resources Institute. **Deep, dark and deoxygenated: Exploring multi-annual hypolimnetic trends in a Great Lakes estuary**.

Inter-annual trends in seasonally recurring hypoxia were examined over a 9-year period in Muskegon Lake - A Great Lakes estuary. Using time-series data from a buoy observatory, temporal changes in dissolved oxygen (DO) and other meteorological and water quality variables were analyzed in surface (2 m) and bottom (11 m) waters. Surface water temperature was the primary driver of hypoxia, controlling other variables including chlorophyll a concentration and water-column stratification. A general decline in the frequency and severity of hypoxia (DO 4.0 mg/L) was observed over the years 2011-2019, decreasing at a rate of ~3 days of hypoxia duration per year, although such decreases may be due to variable episodic oxygenated cold-water intrusions from Lake Michigan. Recent return to severe hypoxic conditions in some lakes despite nutrient reductions suggests that greater weight be placed on regional climate projections when managing lake ecosystems.

L. Birt, L. Montestruque, Xylem, Xylem Digital Solutions; P. Henthorn, Xylem; J.L. Tank, University of Notre Dame, Department of Biological Sciences; K. Simpson, Xylem, Advanced Technology and Innovation Team; C. Palassis, Xylem, Sensor Development/Engineering; C. Forestieri, E. Fullert, Van Buren Conservation District. **Nutrient Reduction through Real-Time Optimization and Control**.

Managed drainage installed to maintain increased crop production have also increased non-point source loss from agricultural land by facilitating export of excess nutrients unused by growing crops to downstream rivers and the Great Lakes (GL) region. Xylem, in partnership with the University Notre Dame and Van Buren Conservation District, produced a "proof of concept" dynamically controlled drainage water management (DC-DWM) for agricultural nutrient management in the GL region. To achieve this, the team integrated sensors with a data-driven model to dynamically control the tile drainage and quantify the reduction in nutrient losses from two agricultural field plots in Paw Paw Watershed in Michigan. This presentation will highlight the high-frequency in-situ sensors (i.e. Xylem/YSI EXO2 water quality sonde) installed, telemetry equipment deployed, and the tile flow and grab sample data analyzed for water chemistry to develop data-driven models which will be used to predict the outcomes of changing the flow control structures at the drainage tiles.

L.J. Blume, USEPA Region 5 Great Lakes National Program Office, Sci. & Quality Assurance Branch (SQAB), Lab. Services; M. Middlebrook Amos, GDIT; C.J. Palmer, General Dynamics Information Technology; T. Lewis, GDIT; B. Fevold, Sole Proprietor, Science and Engineering. **Can't have one without the other: the marriage of quality systems and adaptive management**.

Adaptive Management (AM) is a common keyword cited in ecorestoration literature. Project managers often do not describe how AM will inform restoration approaches or improve decision making. Evaluation of project success relies on clear, measurable objectives that inform subsequent actions. Project-level AM is a tool that can move the project forward in the face of uncertainty, allowing for adjustment in strategies over time. Just as quality oversight reduces measurement error propagation during data collection, the same quality oversight must be implemented for AM. Quality systems should be designed to reduce uncertainty during all AM phases. This presentation describes what AM is & is not by considering key components of AM (including people & communication!) and their linkage into QA/QC principles and activities. The projects & lessons learned used here are based on USEPA's GLRI's Quality Program that has assisted the federal investment of >$3B in the Great Lakes restoration since 2010.

S.A. Bocaniov, University of Waterloo (Ontario), Earth and Environmental Sciences; K.G. Lamb, University of Waterloo (Ontario), Department of Applied Mathematics; Y. Rao, Environment and Climate Change Canada; R.E. Smith, University of Waterloo (Ontario), Biology Deptment. **High Sensitivity of Lake Hypoxia to Physical and Nutrient-Related Anthropogenically Induced Forcings**.

A three-dimensional hydrodynamic-ecological model is applied to Lake Erie to predict the response of dissolved oxygen (DO) to independent changes in air temperature, wind speeds and total phosphorus (TP) loading. Warmer temperatures and lower wind speeds increased the size and duration of hypoxic and anoxic regions by lengthening the stratified period. Decreased wind speed increased hypolimnion thickness while decreasing its temperature and DO consumption rate. Decreased TP loading improved DO conditions with a reduction of 75% effectively abolishing hypoxia. Anoxia was more sensitive to air temperature, wind and nutrient changes than was hypoxia. Over most of the relevant range of forcing factors, the simple and first order effect of a 1 °C temperature change was equivalent to a 10-14% change in TP loads, while a 1% change in wind speed was equivalent to a 2-3% change in TP loads. Reduced ice cover in warmer climates will likely increase air temperature effects even further. [S1] [S1]Must be no more than 1000 characters with spaces and written as one paragraph

H.A. Bootsma, University of Wisconsin-Milwaukee, School of Freshwater Sciences; B. Turschak, Michigan Department of Natural Resources; G.K. Tarsa, N. Van Ee, University of Wisconsin-Milwaukee, School of Freshwater Sciences; B.M. Lafrancois, National Park Service. **Life without mussels: Benthic community response to a mussel removal experiment**.

To assess the effect of dreissenids on benthic nutrient dynamics and community composition, we are conducting a long-term experiment in which quagga mussels have been manually removed from a 40 m2 area on an offshore rocky reef near Sleeping Bear Dunes National Lakeshore, Lake Michigan. Four years after mussel removal, virtually no mussels have recolonized the area. Benthic algae biomass remains relatively high on mussel-free rocks. However, algae on these rocks has a lower phosphorus content and differs taxonomically from algae on control rocks, and the abundance of all benthic invertebrates is much lower than on control rocks. We hypothesize that mussel recolonization is inhibited by round goby feeding, while the persistence of high algal biomass suggests light is an important driver of algal growth. Results to date suggest that mussel removal

from larger areas would have long-term effects on benthic nutrient dynamics, trophic structure and energy flow.

K. Bosse, M.J. Sayers, R. Shuchman, Michigan Technological University, Michigan Tech Research Institute; J. Lekki, R. Tokars, NASA, Glenn Research Center. **Impact of COVID-19 Shutdowns on Water Quality in the Great Lakes**.

The states of Ohio and Michigan issued shelter-in-place orders in March 2020 in response to the COVID- 19 pandemic. The resulting idle factories, reduced commuter traffic, and changes in the timing of agricultural practices could lead to changes in Great Lakes water quality. This study uses a historic remote sensing data record to explore whether changes in human activity during the pandemic can be detected from Earth observing satellites. The analysis focuses on the western basin Lake Erie (WBLE), Saginaw Bay, Lake Huron (SBLH) and Thunder Bay, Lake Huron (TBLH). WBLE and SBLH are each heavily impacted by human activity while TBLH has a much lower human impact. Using remote sensing derived estimates of chlorophyll (CHL), suspended sediments (TSS) and water clarity, this analysis compares 2020 to the historic baseline to identify periods of anomalous water quality. Harmful algal bloom extents were also analyzed in WBLE. Notable changes were only observed in SBLH, with prolonged periods of elevated CHL and decreased TSS. Further research is needed to determine if these changes are related to the shift in human activity or if they are a result of natural variability.

K. Almack, Ontario Ministry of Natural Resources; A.T. Duncan, Chippewas of Nawash Unceded First Nation #27, Fisheries; A.J. Reid, University of British Columbia, Institute for the Oceans and Fisheries; N.W. Boucher, Great Lakes Fishery Commission, Science Program. **Dialogue Session on the Two-Eyed Seeing Approach in the Great Lakes (60 min)**.

In this session, we will be facilitating a conversation with conference participants, panelists and presenters. The purpose of this session will be to give everyone an opportunity to share experiences and insights about bridging knowledge systems between Indigenous and non-Indigenous communities. The session will be facilitated over the Zoom platform and will include breakout groups as well as open discussion where we will harvest key insights. In small groups, participants will share their experiences and have a discussion about both the challenges and opportunities of using the two-eyed seeing approach. We will collectively share our reflections large group circle to develop recommendations. We hope that this session will provide an opportunity to build relationships, facilitate co-learning, and generate recommendations on how to ethically and equitably apply the two-eyed seeing approach to support sustainable management of Great Lakes ecosystems.

N.W. Boucher, Great Lakes Fishery Commission, Science Program. **Traditional Opening Ceremony**.

Traditional opening ceremony

N.W. Boucher, Great Lakes Fishery Commission, Science Program. **Traditional Opening Ceremony - Part 2**.

Part two of the opening ceremony.

N.W. Boucher, Great Lakes Fishery Commission, Science Program. **Traditional Closing Ceremony**.

This ceremony will close Session 25.

G. Boudreaux, U.S. Army Corps of Engineers, Chicago District, Planning Branch, Economic Formulation Section; F. Lupi, Michigan State University, Agricultural, Food, and Resource

Economics & Fisheries and Wildlife; B. Sohngen, A. Xu, The Ohio State University, Department of Agricultural, Environmental, and Development Economics. **Great Lake beach visitor preferences toward harmful algal bloom and bacterial warnings**.

This paper estimates beachgoers preferences for beach quality attributes including sand quality, water clarity, and avoidance of current or previous warnings for harmful algal blooms (HABs) or bacteria. Data were collected at public beaches around Lake Erie and Lake St Clair. Following a randomized sampling schedule, interview teams went to 28 sandy beaches from the Eastern Ohio border to Northern Lake St Clair. Randomly selected visitors were interviewed and sent a follow-up survey to measure their preferences for beach attributes. We find the average respondent is willing to drive over 200 miles to avoid sites with either HAB or bacterial warnings in place and there was a negative lag effect for both types of warnings that remains at least 6 days after warnings are lifted. While respondents are equally as averse to currently active HAB and bacterial warnings, this aversion decreases at a slower rate after a bacterial warning is lifted.

L. Bourgeau-Chavez, Michigan Technological University, Michigan Tech Research Inst.; M. Battaglia, A.F. Poley, C.N. Brooks, Michigan Technological University, Michigan Tech Research Institute; D.J. Leisman, J. Graham, Michigan Technological University, Mich Tech Res. Inst; B. Brisco, Natural Resources Canada, Centre for Mapping and Earth Observation; L. White, S. Banks, Environment & Climate Change Canada, Environment & Climate Change Canada; P. Morin, University of Minnesota, Polar Geospatial Center; K. Pelletier, University of Minnesota, Remote Sensing and Geospatial Analysis Laboratory; J. Klassen, SharedGeo.org, Petascale Computing; B. Huberty, SharedGeo, National Wetland Inventory. **Progress on Developing a Framework for Monitoring Coastal Wetlands with High Resolution Satellite Imagery in 4D**.

In 2016, a binational team began working on developing a framework for monitoring coastal wetlands of the Great Lakes in 4D using high resolution Digital Globe optical and Radarsat-2 synthetic aperture radar (SAR) satellite imagery. Five institutions are working together to acquire the data, develop automated algorithms, process the big data and serve up products. Currently, the team is assessing products for: 1) helping streamline the traditionally arduous process of updating of the National Wetland Inventory; 2) evaluating breeding habitat of a threatened shorebird; and 3) to aid in monitoring wetland gain and loss while accounting for the naturally fluctuating lake levels. Small changes in hydrology can lead to large changes in surface water extent causing wetlands to change type or even disappear (at the wetland/upland interface and shoreline). The goal is to develop radar and optical remote sensing semi-automated analysis methods to routinely monitor the dynamic nature of Great Lakes coastal wetlands to help wetland managers and decision makers assess wildlife habitat conditions, restoration activities and wetland health.

A.J. Bramburger, Environment and Climate Change Canada, Watershed Hydrology and Ecology Research Division; C.T. Filstrup, E.D. Reavie, University of Minnesota Duluth, Natural Resources Research Institute; C. Sheik, University of Minnesota Duluth, Biology and Large Lakes Observatory; G.D. Haffner, Great Lakes Institute for Environmental Research University of Windsor; D.C. Depew, Environment and Climate Change Canada, Watershed Hydrology and Ecology Research Division; J.A. Downing, Minnesota Sea Grant. **The plenism of the plankton; or, Cyanobacteria abhor a vacuum**.

Increasingly frequent HABs and related public health threats have sparked interest and funding in HAB prediction. This focus has insulated HAB research from the wider field of phycology. Many recent studies characterize "ideal" conditions for HAB development and toxigenesis by quantifying autecological optima for HAB species *outside* of broader community dynamics. This approach treats nominal cyanobacteria species as specialists, released from eukaryote competition. Given their lengthy evolutionary history, flexible genomes, and ambiguous taxonomy,

cyanobacterial "species" are better described as generalists.Despite some cyanobacteria showing resource optima in the lab, their response to stressors in nature reflect their realized niche - influenced by responses of specialist competitors. We synthesize genomic, taxonomic, and ecological findings to demonstrate why robust models of HAB development and toxigenesis are unattainable without evaluation of the entire phytoplankton community.

J.F. Bratton, LimnoTech; J. Hortness, U.S. Geological Survey; S. George, Environment and Climate Change Canada; S. Wortman, U.S. Environmental Protection Agency; C. Stow, NOAA Great Lakes Environmental Research Laboratory; S. Goehl Duncan, GDIT (now U.S. Department of Energy); T. Lewis, GDIT; J. Schofield, General Dynamics Information Technology; W. Michaud, GDIT.
Lessons learned about quality systems in developing an adaptive management framework for Lake Erie.

The U.S. and Canada are developing an adaptive management framework for implementing the Lake Erie Binational Nutrient Management Strategy. Components of the framework that require consideration of quality system principles include best management practice tracking programs in watersheds; water quality monitoring networks; numerical models; aircraft and satellite remote sensing systems; and governance systems including technical peer review and stakeholder feedback functions. Some form of each of these critical components exists for Lake Erie, and efforts are being made to better synchronize and consolidate data collection and analysis, and to improve quality and consistency along the way. Because not all components of a high-performing adaptive management program exist yet, the focus to date has been on building a framework to describe and connect what currently exists, and on charting a course toward the development of a more complete, effective, and resilient system in the future.

J. Breidenbach, A. Lad, D.J. Kennedy, S. Haller, The University of Toledo College of Medicine and Life Sciences. **Exposure to Aerosolized Harmful Algal Bloom Toxin Microcystin-LR Induces Inflammation of the Airways**.

Harmful algal blooms are on the rise globally and pose serious health concerns due to the release of cyanotoxins, which are harmful to both humans and the environment. Cyanotoxin microcystin-LR (MC-LR) has recently been detected in aerosols generated by the normal motions of affected bodies of water. However, the human health effects of MC-LR aerosols on pulmonary health remain largely unknown. The objective of this study was to determine the extent of the pro-inflammatory effects of MC-LR on the airways to elucidate the implications of exposure in healthy and at-risk human populations. To address these knowledge gaps, an in vitro 3D primary human airway model was used. Mouse inhalation exposures to MC-LR were also investigated. Both human airway model and mouse model demonstrated a significant increase in inflammation following exposure to aerosolized MC-LR. These results warrant further investigation into the potential impact of MC-LR aerosol exposure in at-risk human populations.

T.O. Brenden, J.R. Bence, Michigan State University, Department of Fisheries and Wildlife. **A combined Lakes Huron and Michigan catch at age model for Chinook salmon accounting for movement between lakes**.

Catch-at-age (CAA) models are widely used in the Great Lakes for estimating abundances and mortalities for fish populations. For many species, CAA results are used along with harvest policies to set safe harvest levels for exploitive fisheries. For other species, CAA results are used to estimate prey consumption levels and to determine safe stocking levels. For Chinook salmon in Lakes Michigan and Huron, CAA models have previously been constructed to determine prey consumption levels. These previous CAA models have either ignored that Chinook salmon move between the lakes or have accounted for movement in a simple manner. We constructed a combined

Lakes Michigan and Huron CAA model for Chinook salmon that explicitly accounted for movement between the lakes. The combined-lake model was fit to multiple data sources including recreational harvest and harvest age composition. Other data sources included percentage of the populations that were wild-produced and the fraction of Lake Michigan harvest that was Lake Huron stocked fish. The results of the combined-lake SCAA model for Chinook salmon will be discussed, including implications to estimated prey demand.

L. Brinks, T. Kearns, Great Lakes Observing System, Data Management. **Lakebed 2030: Building a Better Bathymetric Basemap for the Great Lakes**.

Encompassing eight U.S. states and the second largest province in Canada, the Great Lakes region is home to 60 million people and accounts for more than 50% of trade across the US/Canada border. But today, we lack an accurate picture of what the bottom of the Great Lakes looks like. Commerce, maritime safety, recreators, utilities, science, engineering, and infrastructure all utilize and leverage what the lakes have to offer without a comprehensive understanding of the underwater topography. Without this critical information the full impact of climate change, shipping routes, fisheries and minerals management, benthic habitats, and recreation cannot be realized. GLOS and partners intend to build a coalition of stakeholders, data providers, investors, and technologists to develop and execute a plan for high-resolution mapping of the Great Lakes. The benefits of this effort will provide a foundational dataset for economic growth, scientific research, maritime safety, security, and recreational use. Lakebed 2030 supports the need for comprehensive, timely, and accurate data about the Great Lakes from the surface, all the way down.

C.N. Brooks, A. Grimm, Michigan Technological University, Michigan Tech Research Institute; A.M. Marcarelli, Michigan Technological University, Biological Sciences; N. Marion, R. Dobson, Michigan Technological University, Michigan Tech Research Institute; C. Huckins, Michigan Technological University, Biological Sciences; R. Shuchman, M.J. Sayers, Michigan Technological University, Michigan Tech Research Institute. **Applying multispectral drone data to identify extent of Eurasian watermilfoil in northwest L. Huron**.

Eurasian watermilfoil, Myriophyllum spicatum or EWM, is a non-native submerged aquatic vegetation (SAV) species that forms thick, often monotypic beds in littoral zones, with significant negative environmental impacts. Use of a modified normalized difference vegetation (NDVI) index provided significant differences among SAV. We deployed natural color and multispectral imaging systems for an unmanned aerial vehicle (UAV/drone) at 5 sites in the Les Cheneaux Islands in northwestern Lake Huron, Michigan. Object-based image classification resulting in site maps with overall 76.7% accuracy, higher than most previous efforts despite some sites having limited water clarity. Classifications before and after three types of restoration treatments showed it was possible to quantify the reductions of 63-89% in EWM extent. These results help demonstrate that UAS-enabled multispectral sensing is able to provide a tool for monitoring treatment effects and improving understanding of aquatic ecology.

R. Brouwer, University of Waterloo, Department of Economics; R. Pinto, University of Waterloo, Department of Earth and Environmental Sciences; D. Dupont, Brock University, Department of Economics. **What are the Great Lakes worth?**

Public awareness and understanding of water quality issues in the Great Lakes Basin is limited. A large-scale survey was therefore implemented across Ontario and the 6 US states bordering the Great Lakes to assess public perception and valuation of water quality. Estimating public willingness to pay can be used to initiate conversations about and justify future investments in water quality improvements in the Great Lakes. Canadian and US residents generally value water quality improvements and are willing to pay for these improvements over and above their current water bill.

However, public WTP differs across lakes and ecosystem services associated with water quality improvements. Although hypothetical, public WTP estimates provide important value cues about what the Great Lakes are worth to taxpayers and the potential cost recovery of future investment decisions in the Great Lakes Basin.

A.M. Brown, Cleveland State University; A. Erf, Youngstown State University; D.L. Bade, Kent State University, Biological Sciences. **An early alert system for harmful algal blooms in Lake Erie**.

Ecological theory suggests that statistical indicators (e.g. variance) of key ecosystem parameters may portend a shift in an ecosystem's state. The goal of this study was to investigate whether variance in phycocyanin data could generate an early warning of harmful algal blooms in Lake Erie. We used the Quickest Detection (QD) method to track the variance of phycocyanin data collected from a buoy near the Toledo water intake relative to data from two other locations (Stone Lab and Cleveland) from 2015-2018. The QD method calculates the likelihood that the variance observed from a rolling window was within a baseline state or whether it indicated a transition to an alternate state. If the QD statistic exceeded a user-defined threshold, an alarm was generated. The QD method successfully produced an alarm prior to the large 2017 bloom and failed to produce alarms for the smaller 2016 and 2018 blooms. This method is well suited for real-time monitoring of high-frequency in-situ sensors.

S.D. Buchholz, T.W. Davis, Bowling Green State University, Biological Sciences; S.R. Bickman, LightDeck Diagnostics; G.J. Doucette, NOAA; T. Bridgeman, University of Toledo, Lake Erie Center & Dept. of Environmental Sci.; E. Verhamme, LimnoTech; J.D. Chaffin, Stone Laboratory, Ohio State University; T.H. Johengen, University of Michigan, Cooperative Institute for Great Lakes Research (CIGLR); H.L. Purcell, University of Michigan CIGLR, CIGLR; J.F. Bratton, G. Cutrell, LimnoTech; J. Kerns, ODNR - Old Woman Creek NERR; F.A. Martinez, NOAA/National Centers for Coastal Ocean Science. **Second generation cyanotoxin detection technology in routine monitoring and citizen science groups**.

Current sampling methods are insufficient to quantitatively measure cyanotoxins, such as microcystins and other emerging cyanotoxins of concern such as saxitoxins and cylindrospermopsins. The second generation LightDeck MC/CYN HAB Toxin Detection System is a user-friendly technology capable of accurate measurements of microcystins and cylindrospermopsins that will yield toxin data more efficiently and conveniently than the current EPA-validated Microcystin ELISA method. The LightDeck Toxin Detection System is being implemented by citizen science groups in western Lake Erie as well as university-led Lake Erie water quality monitoring programs. These coordinated efforts not only provide data to validate LightDeck against the validated laboratory method, but also assess the practicality of the instrument itself. A total of 302 comparison samples were collected and analyzed between collaborators. Ongoing laboratory experiments will continue to evaluate the accuracy of the instrument.

J. Burbank, University of Waterloo; Fisheries and Oceans Canada; A. Drake, Fisheries and Oceans Canada, Great Lakes Laboratory for Fisheries and Aquatic Sciences; M. Power, University of Waterloo. **Seasonal prey consumption by an imperiled small-bodied fish is influenced by riparian vegetation**.

The exploitation of terrestrial prey highlights the functional value of adjacent terrestrial habitats but is not well understood for many small-bodied fishes. We determined the diet and consumption of terrestrial prey by an imperilled fish, Silver Shiner, and found Silver Shiner to be a generalist drift feeder that consume a wide range of aquatic and terrestrial prey. In fall, when bankside terrestrial invertebrates were more abundant, Silver Shiner stomachs contained significantly

more terrestrial prey in reaches where riparian vegetation cover was highest, indicating reaches with intact riparian cover are important habitats for Silver Shiner by facilitating access to high quality prey. The consumption of terrestrial prey may be particularly important in fall as terrestrial prey is energy dense and may promote increased growth and survival, leading to successful overwintering. We conclude that terrestrial subsidies are essential for Silver Shiner and the protection and maintenance of reaches with intact riparian habitats would help ensure access to prey resources important for the sustainability of Silver Shiner populations.

L.E. Burlakova, A.Y. Karatayev, SUNY Buffalo State College, Great Lakes Center; K. Mehler, S.E. Daniel, SUNY Buffalo State, Great Lakes Center; J.A. Nestlerode, US. EPA Office of Research and Development, Center for Environmental Measurement and Modeling; M. Pawlowski, E.K. Hinchey Malloy, U.S. EPA, Great Lakes National Program Office; M. Wick, University of Minnesota Duluth, Water Resource Sciences. **Exploring Great Lakes Benthoscapes: Can we visually delineate freshwater benthic communities?**

Our limited knowledge of freshwater benthic habitats poses challenges for effective management to protect habitat and species diversity. Despite our increasing capability to map benthic habitats, our ability to quantify benthos, particularly for organisms living in the sediments, is constrained by small spatial scales of traditional sampling. During the 2019 Lake Erie Cooperative Science and Monitoring Initiative benthic survey we enhanced the traditional collection of Ponar grabs with underwater videos using Drop-down GoPro cameras and Sediment Profile Imaging camera. We classified benthic habitats based on analysis of the images for presence and relative abundance of benthic taxa, verified images against data from Ponars, and compared results with water quality data collected via the Sea-Bird profiler casts. Benthic taxa abundant in identified habitat types differed in their tolerance to hypoxia, indicating that near-bottom oxygen availability structures Lake Erie benthoscapes.

C. Burmaster, University of Windsor, Real-Time Aquatic Ecosystem Observation Network; R. Miller, University of Michigan, Cooperative Institute for Great Lakes Research (CIGLR); J.A. Austin, University of Minnesota, Duluth, Large Lakes Observatory; P. McKinney, ORISE, US EPA Office of Research and Development, CCTE/GLTED; M. Xenopoulos, Trent University, Biology; J.C. Hoffman, T. Hollenhorst, US EPA, Great Lakes Toxicology and Ecology Division; A.T. Fisk, University of Windsor, GLIER. **A framework for collaborative glider operations in the Great Lakes**.

Autonomous underwater vehicles (AUVs) provide the opportunity to observe aquatic environments and collect high-resolution data over large spatial and temporal scales. AUVs, particularly gliders, have become more prevalent in the Great Lakes in recent years. With several observatories in the region now using gliders, the opportunity exists for institutions to more efficiently operate in the Great Lakes through collaboration. Collaboration is especially advantageous in the presence of considerable restrictions as seen in 2020. For the 2021 field season, the Real-Time Aquatic Ecosystem Observation Network (RAEON) and the Cooperative Institute for Great Lakes Research (CIGLR) have partnered with the Environmental Protection Agency (EPA) and University of Minnesota Duluth (UMD). Here we present a framework for collaborative glider operations, including goal setting and mission planning; data processing and analysis; training; deployment and recovery of equipment; and cooperative piloting.

P.A. Bzonek, University of Toronto Scarborough; A. VanNynatten, University of Toronto Scarborough, Biological Sciences; N.E. Mandrak, University of Toronto Scarborough, Department of Biological Sciences. **Acoustic deterrent to stop invasive cyprinid: phylogenetic signal found in a fish-community response**.

Non-structural deterrents may limit invasive fish dispersal and range expansion without altering waterflow. Despite extensive research in laboratory and artificial environments, few studies have been conducted in situ and, of those, few have evaluated the full community response of fishes interacting with the deterrent. We deployed acoustic deterrents within a physical trap-and-sort fishway at Cootes Paradise, Ontario, Canada, to determine the avoidance responses of a community of fishes attempting to disperse into the wetland. To test the effectiveness of an acoustic deterrent, the catch rates of fishes entering Cootes Paradise were compared when the deterrent was off (control) and on (treatment). Over 11 500 fishes, representing 12 families, were captured. The acoustic deterrent produced a significant phylogenetic signal in species-specific avoidance responses, but did not alter the Shannon diversity of fishes challenging the fishway. There was a modest decrease in the catch rates of Common Carp (ambient trials =1.03 fish/hour, deterrent trials = 0.84 fish/hour), a species of major management concern.

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B.C. Cahill, S.E. Hansen, Central Michigan University, Earth and Ecosystem Science; A.K. Monfils, Central Michigan University, Department of Biology and Institute for Great Lakes Research.
Development and Application of an Adaptive Management Framework for European Frog-bit Management.

European frog-bit (*Hydrocharsis morsus-ranae* L.; EFB) is a free-floating aquatic plant invasive to North America. First recorded outside of cultivation in North America in Ontario in 1939, EFB has been documented in four U.S. states and one Canadian Province in the Laurentian Great Lakes Region. In Fall of 2018, a team of biologists, land managers, and state and federal agencies formed a European Frog-bit Collaborative with the goal of integrating EFB management, monitoring, and research efforts in Michigan into an adaptive management framework (AMF). The resulting AMF contains strategies to inform and support on-the-ground management to contain existing high-risk infestations, mitigate impacts in invaded high-value wetlands, and protect uninvaded high-value wetlands from invasion. We will present on the current state of knowledge on EFB biology and ecology, provide an overview of the EFB AMF, and discuss efforts to apply the AMF and its strategies on a local jurisdiction level.

J. Callaghan, University of Minnesota Duluth, Biology Department and Large Lakes Observatory; E.D. Reavie, University of Minnesota Duluth, Natural Resources Research Institute; A.J. Bramburger, Environment and Climate Change Canada, Watershed Hydrology and Ecology Research Division; C. Sheik, University of Minnesota Duluth, Biology and Large Lakes Observatory.
Spatial and temporal patterns of Cyanobacteria in Lake Superior.

The microbiology of the Laurentian Great Lakes (LGL) has been grossly understudied, especially in Lake Superior. Microorganisms drive the cycling of life sustaining elements, e.g., nitrogen, phosphorus, and carbon, through what is termed the 'microbial loop'. Microorganisms are crucial food sources in aquatic environments. Thus, what happens in the microbial loop has consequences for the entire food web. Using DNA-based approaches we assess and compare the composition and function of microbial assemblages across Lake Superior. We find that microbial community patterns are not fully explained by the nearshore to offshore gradient, but may be influenced by currents. Furthermore, we highlight Cyanobacteria that are endemic to Lake Superior, including a novel genus in the *Cyanobiaceae* family, by comparing current populations to those found in the sedimentary record.

A. Camilleri, Cooperative Institute for Great Lakes Research, University of Michigan; A.K. Elgin, NOAA Great Lakes Environmental Research Laboratory, Lake Michigan Field Station; G. Kennedy, United States Geological Survey; M. Wensman, G. Carter, Cooperative Institute for Great Lakes Research. **Dreissenid mussel distributions in Western Lake Erie in 2018 and 2019: Implications for Hexagenia**.

Dreissenid mussels have been found to increase the overall abundance of benthic invertebrates through added habitat and food availability. Studies have demonstrated that the effects of dreissenids on hexagenia are complex. Mussels may inhibit burrowing, but also provide shelter and increased food availability. To examine the effect of dreissenids on hexagenia, we present recent spatial distribution data for dreissenids and hexagenia from a long-term benthic sampling program in western Lake Erie. Dreissenid density showed no significant correlation with hexagenia density (Spearman rank correlation, p=0.66). However, samples with a total dreissenid density greater than 20660 individuals/m2 had significantly higher hexagenia densities than samples with fewer mussels (Wilcox rank sum test, p=0.02). Our results suggest that dreissenid density is an important factor influencing western Lake Erie hexagenia populations, but other factors are likely at play.

S. Cardiff, University of Wisconsin-Madison; J. Coleman, E. Chiriboga, Great Lakes Indian Fish and Wildlife Commission, Environmental Section; S. Ventura, University of Wisconsin-Madison. **Cumulative extent of iron mine influence on water quality in Lake Superior Ojibwe Territories**.

Contamination from iron mining can affect fish, wildlife, and plants that are of importance for Indigenous lifeways and treaty rights. Evaluating the extent of such contamination will contribute to understanding of the cumulative impacts of mining. Such evaluation requires classifying waters as mine-influenced or not mine-influenced, but studies have yet to identify appropriate water quality characteristics and classification methods. We assessed the accuracy of two classifiers using specific conductance and major anion data from the Water Quality Portal, from our own field work, and from additional reports. We determined that overall classification accuracy tested against validation data was greater for most combinations of anions using a Discriminant Function Analysis (DFA) rather than a Support Vector Machine classification. DFA results indicated that at least 900 river-km in the iron mining zones of the Lake Superior Ojibwe Treaty-ceded Territories were mine-influenced during at least a portion of the years 2000 through 2020. Additional water sampling is necessary, but these results indicate extensive mine influence and potential impacts.

H.J. Carrick, Central Michigan University, Biology & Institute for Great Lakes Research; C. VanCuren, Central Michigan University, Biology & Institute for Great Lakes Reseach; V.J. Denef, University of Michigan, Ecology and Evolutionary Biology; A. Camilleri, Cooperative Institute for Great Lakes Research, University of Michigan; G. Carter, Cooperative Institute for Great Lakes Research; C.M. Godwin, University of Michigan, Cooperative Institute for Great Lakes Research; T.H. Johengen, University of Michigan, Cooperative Institute for Great Lakes Research (CIGLR); A.K. Elgin, NOAA Great Lakes Environmental Research Laboratory, Lake Michigan Field Station; P. Glyshaw, NOAA Great Lakes Environmental Research Laboratory; H.A. Vanderploeg, NOAA GLERL. **Dreissenid Mussel Grazing on Small Plankton Promotes Harmful Algal Blooms in Lake Erie**.

The recent proliferation of harmful algal blooms in the western basin of Lake Erie is unexpected change, given the improvements in water quality throughout the lake. Previous studies showed that invasive mussels (Dreissena) are capable of feeding on a range of particles, although this work did not evaluate grazing effects on intact plankton assemblages. Five mussel feeding experiments were performed in 2018 (May, June, July August, October). Pre- and post-grazing samples were collected from seven 20-L mesocosms (3 control, 4 mussel treatments), and analyzed

using microscope cell counts. Results from our experiments showed that Dreissena were active grazers of plankton on all dates, although their clearance rates (mL/mg, h) were variable among taxonomic groups (range 1.70 to 25.00, mean ± SE 11.70 ± 1.33). We measured high Dreissena clearance rates on nano-sized cryptomonads and centric diatoms (ca 20 μm), and lower rates on cyanobacteria (e.g., Microcystis, ANOVA, p 0.05). These results showed that mussels were major consumers of plankton in the western basin of Lake Erie, and that their differential grazing can shape plankton taxonomic composition.

L. Chadderton, A. Tucker, M. Herbert, The Nature Conservancy; D. Clapp, Michigan DNR Fisheries Division; T. Galarowicz, Central Michigan Univ.; J.T. Kvistad, Central Michigan University; K. Snyder,, P. O'Neill, J. Milan, Michigan DNR, Fisheries Division; D. Castle, Little River Band of Ottawa Indians; J.L. Jonas, Michigan Department of Natural Resources. **Rusty Crayfish on native fish spawning reefs. Can fall suppression reduce overwinter egg predation?**

Crayfish impacts on spawning reefs in the Great Lakes are well documented with evidence that egg predation may hinder attempts to rehabilitate populations of Lake Trout, Cisco and Lake Whitefish. Here we report on efforts to suppress Rusty Crayfish on two reefs in Northern Lake Michigan prior to arrival of fall spawning native fish. We implemented intensive trapping across each reef and neighboring habitats, augmented with experimental barriers deployed to slow crayfish recolonization. Spatial patterns in trapping data and measurements of crayfish density indicate a reduction in crayfish density on one reef. But evidence from a tagged crayfish population within the treatment area suggested limited barrier effectiveness. Egg net seeding and recovery in combination with long term lake trout egg deposition data did not provide evidence that crayfish suppression resulted in a reduction in lake trout egg predation, although late fall storm impacts on reef egg retention and low wild egg deposition were confounding factors. We discuss lessons from this and previous suppression studies and implications for future spawning reefs restoration efforts.

J.D. Chaffin, Stone Laboratory, Ohio State University; J.F. Bratton, E. Verhamme, LimnoTech; T. Bridgeman, University of Toledo, Lake Erie Center & Dept. of Environmental Sci.; T.W. Davis, Bowling Green State University, Biological Sciences; J. Westrick, Wayne State University, Lumigen Instrument Center; G.J. Dick, University of Michigan, Earth and Environmental Sciences; P. Xue, Michigan Technological University, Civil & Environmental Engineering; R.M. McKay, University of Windsor, Great Lakes Institute for Environmental Research; C. Binding, Environment and Climate Change Canada; A. Zastepa, Environment and Climate Change Canada, Canada Centre for Inland Waters. **The HABs Grab: A binational characterization of the the Lake Erie cyanobacterial blooms**.

Monitoring of cyanobacterial bloom biomass in large lakes at high resolution is made possible by remote sensing. However, monitoring cyanobacterial toxins is only feasible with grab samples, which, results in uncertainties in the spatial distribution of toxins. To address this issue, we conducted two intensive "HABs Grabs" of the western basin cyanobacterial bloom. These were one-day sampling events during August of 2018 and 2019 in which 100 and 172 grab samples were collected, respectively, within a six-hour window covering up to 2,270 km^2 and analyzed using consistent methods to estimate the total mass of MC. The samples were analyzed for 57 parameters, including toxins, nutrients, chlorophyll, and genomics. There were an estimated 11,513 kg and 30,691 kg of MCs in the western basin during the 2018 and 2019 HABs Grabs, respectively. The bloom boundary poses substantial issues for spatial assessments because MC concentration varied by nearly two orders of magnitude over very short distances. The MC to chlorophyll ratio (MC:chl) varied by a factor up to 5.3 throughout the basin, which creates challenges for using MC:chl to predict MC concentrations.

S. Chaganti, University of Michigan, Cooperative Institute for Great Lakes Research (CIGLR); C.M. Godwin, University of Michigan, Cooperative Institute for Great Lakes Research; R.M. Errera, NOAA; T.H. Johengen, University of Michigan, Cooperative Institute for Great Lakes Research (CIGLR); H.A. Vanderploeg, NOAA GLERL. **Impact of environmental conditions in triggering toxin (microcystin) producing strains to bloom**.

The largest blooms, occurring in the western basin of Lake Erie and other Great Lakes, are comprised of the cyanobacterium Microcystis aeruginosa, which can produce a liver toxin known as microcystin. Under certain conditions these toxin-producing blooms can pose a threat to municipal drinking water supplies, as occurred in 2014 in Toledo, OH. One of the major knowledge gaps is what parameters trigger the toxin producing microcystin blooms and how we can better predict their production. Here we used nutrients (N & P) and environmental parameters collected from the western Lake Erie from the past five years and linked with the mcyE toxin producing gene data measured using quantitative real time PCR (qPCR). Results will be presented on common parameters that influence cyanobacterial blooms and that are also specific for toxin producing cyanobacterial microcystin blooms. Further, results will be presented on how mcyE gene measures could be used for early prediction of toxic blooms.

R. Chan, C. Eimers, Trent University, School of the Environment. **Linking Land Use and Agricultural Best Management Practices with Water Quality in the Bay of Quinte**.

The Bay of Quinte is a Z-shaped embayment on Lake Ontario's northern shore designated as an Area of Concern due to its history of eutrophication issues. Remedial measures have led to declines in nutrient loading, but further reductions are needed to meet delisting goals. Understanding the impacts of land use/land cover (LULC) changes on water quality is key for identifying target conservation areas. The objectives of this study were to (a) quantify LULC changes within 18 watersheds draining into the Bay over a 30-year period (1990–2019); (b) examine changes in stream nitrate nitrogen (NO3-N) and total phosphorus (TP) concentrations over the same period; and (c) assess relationships between LULC changes and nutrient concentrations. Urban cover increased and natural cover decreased, whereas agricultural area under row crop production increased. Most watersheds had declining TP concentrations and elevating NO3-N concentrations. Watersheds with largest row crop cover had higher NO3-N concentrations, while associations between TP and LULC were weak. The potential for agricultural best management practices to address nutrient trends will be discussed.

P. Madill, A. Chiandet, Severn Sound Environmental Association. **Integrating subwatershed-scale tributary monitoring guides local decision-making**.

Informed decision making that protects water quality requires integrating all available information. Subwatersheds from six tributaries make up most of the immediate Severn Sound watershed, a delisted Area of Concern on Georgian Bay that is under substantial development pressure. Routine monitoring is conducted at the subwatershed scale for stream temperature, water chemistry, flow and benthic macroinvertebrates, although often not at the same sites or on the same temporal scales. Focusing on one subwatershed as an example, we demonstrate that decision support tools such as thermal stability modelling and mapping, combined with stream health assessments and trend analysis using water chemistry and benthos can help to bridge gaps in datasets. Results are used to support local municipal decision-making in land use planning and operations, and can also be used to guide and prioritize stream restoration efforts and track the impact of stewardship actions.

A. Chiandet, Severn Sound Environmental Association; A. Mcpherson, Georgian College. **Microplastics concentrations in small wastewater treatment plants**.

As a rapidly growing field of research, much is being learned about sources of microplastics, which includes municipal wastewater treatment plant (WWTP) effluent. Currently, there is no information on concentrations of microplastics in WWTP effluent being discharged to Severn Sound, a delisted Area of Concern on Georgian Bay. Sampling was undertaken at four WWTPs, all with tertiary treatment, to determine concentrations and types of microplastics in effluent. Of all microplastics found, 90% were microfibres and 6% were fragments. Total concentrations were lower than expected, and ranged from

E. Chiriboga, Great Lakes Indian Fish and Wildlife Commission, Environmental Section; W.P. Mattes, S.B. Michaels, Great Lakes Indian Fish & Wildlife Commission. **Characterizing Risk of Crude Oil Pipeline Spills to the Anishinaabeg - Gichigami Tribal Fishery and Fish Habitat**.

Crude oil pipelines in the Anishinaabeg-Gichigami (Lake Superior) basin were constructed before environmental protection laws were passed. Therefore, the environmental risk of crude oil spills has, in most cases, never been characterized. Crude oil pipelines pose a risk to aquatic habitats in Lake Superior and the Tribal commercial fishery that depends on those habitats. Using standard GIS techniques as well as lessons learned from past inland oil spills, we developed an assessment of areas that could be impacted by crude oil pipeline spills and examine the consequences for existing Tribal commercial fishing activity in Lake Superior.

E. Chiriboga, Great Lakes Indian Fish and Wildlife Commission, Environmental Section. **A Framework for the Analysis of Impacts from Water Withdrawals in the Anishinaabeg-Gichigami Watershed**.

Hundreds of groundwater wells and surface water intakes are located in the Lake Superior watershed. Evaluating the extent of impacts to the environment from these water appropriations will contribute to an understanding of cumulative impacts of the built environment to the Tribal traditional lifeway. This evaluation requires database and spatial analysis of existing data at detailed scales and across political boundaries. Following existing guidance on cumulative effects assessments, we chose data metrics and spatial scales appropriate for impact analysis. This presentation will describe methods and rationale we have used to better understand available data on water uses in the watershed and describe preliminary results.

K.M. Chomiak, C.M. Bangkong, Rochester Institute of Technology, Thomas H. Gosnell School of Life Sciences; J.M. Daily, Rochester Institute of Technology, School of Mathematical Sciences; N. Eddingsaas, Rochester Institute of Technology, School of Chemistry and Materials Science; A. Hudson, Rochester Institute of Technology, Thomas H. Gosnell School of Life Sciences; M.J. Hoffman, Rochester Institute of Technology, School of Mathematical Sciences; S.W. Day, Rochester Institute of Technology, Kate Gleason College of Engineering; C. Tyler, N. Wong, R. Diaz, Rochester Institute of Technology, Thomas H Gosnell School of Life Sciences. **Cascading impacts of microplastics on ecosystem function in lakes**.

In the Great Lakes, much of the microplastic debris is deposited in the benthos, necessitating an understanding of impacts on benthic ecosystem function. The benthic oligochaete *Lumbriculus variegatus* is a key ecosystem engineer with demonstrated toxicity by some microplastics. It's not clear, however, if this toxicity impacts the role of L. variegatus in biogeochemical cycling. We addressed this question using a microcosm approach with sediments from an embayment of Lake Ontario. We incubated sediments with eight plastic polymers, with and without worms. Following a 30 d incubation, we measured fluxes of oxygen and nutrients, microalgae, and potential denitrification. Specific polymers reduced the impact of *L. variegatus* on ecosystem metabolism and nutrient cycling, suggesting cascading impacts of microplastics on ecosystem function in lakes.

R. Clark, Michigan State University, Quantitative Fisheries Ctr., Quantitative Fisheries Ctr.; M. Ebener, Michigan State University, Fisheries and Wildlife; J.R. Bence, Michigan State University, Department of Fisheries and Wildlife. **Development of stock assessment units for lake trout in Lake Michigan**.

A common approach for dealing with spatial variation in stock assessments is to divide large systems into smaller, more homogenous units. Choosing the boundaries of the smaller units can be challenging. Here, we describe how this approach was used to divide Lake Michigan into six spatial units for assessment of lake trout. Spatial variation in mortality and recruitment was the primary basis for subdividing the lake, but other practical considerations also played a role. Spatial variation in mortality was primarily caused by differences in fishing regulations and fishing effort across management jurisdictions. Spatial variation in recruitment was caused by differences in numbers and locations of fish stocked, regional differences in natural reproduction, and fish movement. Practical considerations included data sample size issues. Use of this approach has allowed evaluation of regional differences in lake trout populations and has provided a lake-wide assessment as the sum of units.

J. Coleman, Great Lakes Indian Fish and Wildlife Commission, Environmental Section; D.M. White, Great Lakes Indian Fish and Wildlife Commission, Division of Biological Services; E. Chiriboga, Great Lakes Indian Fish and Wildlife Commission, Environmental Section. **From Hand-held to Cloud-based Water Monitoring in the Great Lakes Basins**.

Over 20 years our monitoring program has evolved from hand meters to using cloud-hosted near-live sensor reporting for water quality. Our original focus was on a small number of parameters measured with hand-held units. Measurements were twice a year or quarterly and were accompanied by grab samples for lab analysis. In 2010, we began installing in-stream near-continuous loggers that collected a small number of parameters such as temperature and specific conductance. That near-continuous data, downloaded quarterly, highlighted how quarterly samples grossly under-represent daily, weekly and monthly variability in water quality. In recent years we have shifted our focus from in-stream loggers to multi-parameter sensor packages that report hourly to the cloud. Building solar powered sensor packages and reporting data to the cloud on a near-live basis we are able to track water and climatic conditions at remote sites and identify water quality issues as they arise.

P. Collingsworth, Purdue University, Department of Forestry and Natural Resources; W. Xu, University of Illinois, Civil and Environmental Engineering; R. Kraus, U.S. Geological Survey; B. Minsker, Southern Methodist University, Civil and Environmental Engineering. **Spatio-temporal analysis of hypoxia in the Central Basin of Lake Erie**.

We develop a spatio-temporal geostatistical interpolation framework to estimate the extent of hypoxia in central Lake Erie with data from a network of DO loggers. The framework uses empirical orthogonal functions and Bayesian kriging to identify the spatially-varying temporal pattern and estimate the distribution of hypoxia, including estimation uncertainty. The framework is applied to analyze spatio-temporal dynamics of DO in the central basin of Lake Erie, using data sampled from a logger network placed on the lake bottom during the summers of 2014, 2015, and 2016. Cross-validation results demonstrate that the framework is capable of capturing the dynamic nature of bottom hypoxia over offshore areas, but nearshore areas have poor interpolation performance due to the impacts of complex physical processes such as seiche events. The prediction error of the overall spatial extent of hypoxia was as large as 25% of the interpolation area based on current logger deployment. Based on the cross-validation and interpolation error, we suggest placing more loggers in nearshore areas to reduce prediction error near the margins of the hypoxic zone.

T. Connolly, X. Zhu, Fisheries and Oceans Canada, Arctic and Aquatic Research Division.
Ecological drivers of zooplankton community characteristics in an Arctic great lake.

Zooplankton community characteristics can be affected by within-lake and lake-river interactions including lake morphology, depth-specific thermal stratification, and river-inflow turbidity. We hypothesized these ecological drivers would be correlated with spatial patterns, species richness, and abundance of zooplankton communities for the oligotrophic lake, Great Slave Lake (GSL), Northwest Territories, Canada. To assess, data was collected from randomly-selected grids across the main basin of GSL (245 grids at 86.49 km^2 per grid) during summers 2012-2016. Depth-specific vertical net tows revealed zooplankton samples predominantly comprised of Calanoida (IRI=52%) and Cyclopoida (IRI=29%), with Mysidae and various Cladocera also present. Detrended correspondence analysis (DCA) revealed sampling depth, pH, conductivity, chlorophyll a, and turbidity to be primary forces in determining zooplankton composition along environmental gradients. This study emphasizes the benefits of combining multiple statistical techniques and extensive field collection efforts to explore ecological drivers of low-trophic community composition.

J.K. Connolly, Cornell Biological Field Station, Department of Natural Resources and the Environment; B. O'Malley, USGS, Great Lakes Science Center, LOBS; P. Hudson, USGS Great Lakes Science Center; J.M. Watkins, L. Rudstam, Cornell University, Natural Resources. **Lake Ontario Meiobenthic Harpacticoid Copepod Community Impacted by Nonindigenous Species**.

Harpacticoids are a significant component of the meiobenthos that serve as microdetritivores. In the Great Lakes, the harpacticoid community includes nonindigenous species but the impact of introduced species has not been fully explored. We present a lake wide quantitative assessment of the harpacticoid assemblage of Lake Ontario. Harpacticoids were collected by ponar grab from August to September 2018 as part of the Cooperative Science and Monitoring Initiative (CSMI) survey. We found a community largely of introduced species at shallow depths. The community transitioned from nonindigenous to indigenous species dominance along an increasing depth gradient, suggesting a deep water refuge for native species. Nonindigenous species accounted for 79% of the community at depths 20m, 55% from 20-40m, declining further to 24% at depths >40m. The prevalence of nonindigenous harpacticoids in Lake Ontario indicate that harpacticoids may be among the groups most susceptible to invasive species.

T.K. Cowdery, A. Baker, M. Haserodt, D. Feinstein, R. Hunt, U.S. Geological Survey, Upper Midwest Water Science Center. **Hydrologic change in the St. Louis River Basin from mining in northeastern Minnesota**.

Hydrologic changes in the St. Louis River Basin near the Mesabi Iron Range from iron mining include a 2.2 percent increase in total groundwater flow, a 1.0 percent net increase in seepage to streams, and a 2.7 percent net decrease in areal seepage to the land surface. Groundwater lost through seepage to mines was counterbalanced by groundwater gained by recharge from tailings basins. However, these losses and gains do not occur at the same locations. The hydrologic changes are greatest near mining features, decreasing with distance. In the study area currently, most water enters the ground as areal recharge (about 79 percent) and leaves as seepage to streams (baseflow, 43 percent) and areal seepage to the land surface (mostly to wetlands, 45 percent). These results come from the comparison between two steady-state finite-difference groundwater-flow (MODFLOW) models constructed by the USGS in cooperation with the Minnesota Ojibwe Bands and the Minnesota Pollution Control Agency.

K. Cunningham, Trent University, Department of Environmental and Life Sciences; E.S. Dunlop, ON Ministry of Natural Resources, Trent University. **Temporal trends in larval lake whitefish (Coregonus clupeaformis) density and growth in Lake Huron**.

Lake whitefish (*Coregonus clupeaformis*) are an ecologically and commercially significant species across the Laurentian Great Lakes. Recent assessments in Lake Huron show reduced numbers of young lake whitefish, but the reasons for this decline in recruitment are unknown. In this study, larval fish were sampled from the Fishing Islands region in the main basin of Lake Huron, an important spawning shoal for lake whitefish. Larval fish were collected during two time periods: a historical period (1976–1986) when population abundances were higher, and a recent period (2017–2019) when abundances are low. Annual hatching density and growth rates were compared to determine at what stage the recruitment bottleneck is occurring. Our analysis revealed significant differences in larval density between the two time periods. We also found significant differences in hatching rates and lower larval production in recent years, suggesting that recruitment is being impacted at the larval stage.

Z. Curtis, T. Eyster, H. Liao, Hydrosimulatics INC; S. Li, Michigan State University. **Adaptive Data-enabled Groundwater Management Platform for the Great Lakes Region**.

Because the subsurface is invisible and highly heterogeneous, and issues spanning a multitude of scales are involved, adaptable groundwater management is critical. Yet, characterizing groundwater systems is traditionally a time-consuming process that limits investigators to one model at one scale of interest. We present a cloud-based platform designed for adaptable groundwater analysis in the Great Lakes region, linking large-scale spatial framework data and distributed sensor network data with numerous modeling, visualization, and analysis capabilities. Users can almost instantly visualize groundwater data and create a data-enabled groundwater model that can be improved based on the management applications and new information. A system of "models inside of models" can be interactively developed to capture critical details at different scales of interest. We demonstrate the adaptable nature and diverse capabilities of the platform through several examples at different sites and at different scales in the Great Lakes region, including a basin-scale water budget analysis, and nested, site-scale contaminant transport simulations.

G. Cutrell, LimnoTech; A. Ritzenthaler, LimnoTerch; E. Verhamme, LimnoTech; L.T. Johnson, Heidelberg University, National Ctr for Water Quality Res., National Center for Water Quality Research. **Use of Real-Time Autonomous Nutrient Analyzers in the Maumee River Basin, OH**.

Wet chemistry-based in-situ nutrient analyzers have been used sparingly to monitor riverine and coastal environments but a recent focus by state and federal to better track phosphorus and nitrogen from agricultural lands to Lake Erie has brought a renewed interest in this technology. A study of the effectiveness, ease of use, and applicability to track nutrients was conducted in 2020 at three sites in the Maumee River Basin, OH. One site was located along the Maumee River and the other sites located in highly agricultural upstream tributaries. Part the NCWQR Tributary Loading Program, these sites compare results processed in-situ with a Green Eye Science NuLAB and lab analyzed grab (ISCO) samples. The NuLAB measurements include concentrations of nitrate, TN, phosphate, and TP every two hours. Results will highlight a comparison of the ISCO and NuLAB nutrient data during dry and wet weather events. The trade-offs of using a real-time autonomous nutrient sensor will also be addressed.

G. Cutrell, LimnoTech; A. Ritzenthaler, LimnoTerch; E. Verhamme, LimnoTech; L.T. Johnson, Heidelberg University, National Ctr for Water Quality Res., National Center for Water Quality

Research. **Use of Real-Time Autonomous Nutrient Analyzers in the Maumee River Basin, OH**.

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D

J.M. Daily, M.J. Hoffman, Rochester Institute of Technology, School of Mathematical Sciences.
Modeling the 3D distribution of microplastic in Lake Ontario and Lake Erie.

Mass estimates of plastic pollution in the world's oceans based on surface samples differ by several orders of magnitude from what is predicted by production and input rates. It has been theorized that plastic accumulates in the sediment, or on beaches and nearshore water. This uncertainty indicates the importance of accounting for additional mechanisms driving movement, beyond surface transport, for improved mass estimates. Additionally, as plastic moves away from the surface, it is likely accumulating at lower depths or in the benthos, dictating which organisms are exposed, yet the vertical distribution remains not well understood. The effect these vertical mechanisms can have is dependent on the depth of the water, as greater depths provided more space for vertical movement. Here we present a comparison of the modeled behaviors of microplastics, focusing on beaching and biofouling, in Lake Erie and Lake Ontario, two lakes with different characteristics.

S.E. Daniel, SUNY Buffalo State, Great Lakes Center; L.E. Burlakova, A.Y. Karatayev, SUNY Buffalo State College, Great Lakes Center; P.D. Hebert, University of Guelph, Centre for Biodiversity Genomics; M.E. Pfrender, University of Notre Dame, Department of Biological Sciences & Environmental Change Initiative; D. Lodge, Cornell University; A. Trebitz, U.S. EPA, Office of Research and Development; S. Westergaard, Great Lakes National Program Office, U.S. Environmental Protection Agency. **Great Lakes DNA Barcode Reference Library: Mollusca, Annelida, and Minor Phyla**.

In recent years there has been a push to use genetic information, particularly the relatively cheap and quick CO1 Barcode, to increase the scope of diversity surveys and detection of aquatic invasive species compared with traditional approaches. However, there are unforeseen issues with this quick method of identification that can have significant consequences. The Great Lakes Center at SUNY Buffalo State aims to expand the taxonomic coverage of The Barcode of Life Database (BOLD) DNA library and has assembled a collaborative team including leading barcoding and taxonomic experts for targeted taxa. By preliminary estimations, 70% Annelida, 34% Bivalvia, and 56% Gastropoda, and 70% minor phyla are known from the Great Lakes lack barcodes. We identified nearly 1000 specimens that have been plated and sent in for genetic barcoding. This presentation will focus on difficulties in genetic barcoding, limitations, and suggestions moving forward for understudied phyla commonly found in the Great Lakes. Additionally, we will discuss

progress made by our partners from Cornell and Notre Dame Universities, and recommendations for further research.

S. Simoliunas; L. Darrah,. **Public consultation on the Great Lakes Water Quality Agreement**.

This presentation will discuss the lack of public consultation with regard to implementation of the Great Lakes Water Quality Agreement, and why the public should be consulted on all steps of implementation.

M. Davis, Great Lakes Commission. **Great Lakes Regional Water Use Database: improving data quality**.

The Great Lakes Commission serves as the database repository for water use data under the Great Lakes-St. Lawrence River Basin Sustainable Water Resources Agreement and corresponding Compact, continuing a role is has filled since the 1987 implementation of the "good faith" Great Lakes Charter agreement. Water use data collection and reporting protocols were adopted by the Compact Council and Regional Body in 2009 and subsequently revised in 2016 to continually improve data quality. Efforts to maintain and improve data quality and accuracy are ongoing and have included updates to the online data management system, implementation of a metadata review process, and coordination to increase consistency in diversion reporting format. Water use managers from each basin jurisdiction annually submit data on withdrawals, consumptive uses, and diversions by water use sector, watershed, and source of water. The reported water withdrawal in 2019 was 38.9 billion gallons a day.

H.A. Dawson, University of Michigan-Flint, Biology; M. Allison, University of Michigan-Flint, Computer Science. **Requirements for AUVs for scientific data collection in the Laurentian Great Lakes: A questionnaire survey**.

Using mobile environmental monitoring can aid in gathering ecological data to meet fish community goals in the Great Lakes. To understand data needs that could be collected by mobile sensor networks to inform decision making, we surveyed Great Lakes professionals involved directly and indirectly in such decision making. Basic data that respondents chose as most important to collect were water temperature, dissolved oxygen, chlorophyll *a*, turbidity, and blue-green "algae", which seems to align with variables affecting fish directly or indirectly (through identification of harmful algal blooms). Specialized data chosen as most important were mapping of habitat characteristics, sonar of groupings of fish, and images/video. Results were very similar when respondents were asked where data should be collected in the Great Lakes (i.e., tributaries, nearshore areas, etc.) except respondents indicated that images/video should be collected most in fish spawning habitats.

J.R. DeMarco, K. Brown, Bowling Green State University, Biology; A. Pierce, A. Fisher, SUNY Fredonia, Biology; G.S. Bullerjahn, Bowling Green State University, Department of Biological Sciences; T.W. Davis, Bowling Green State University, Biological Sciences; C. Wigdahl-Perry, SUNY Fredonia, Biology. **Using in situ sensors to determine phosphorus sources driving HABs in Chautauqua Lake, NY**.

Much like western Lake Erie, Chautauqua Lake is prone to harmful algal blooms (HABs) each year. HABs, hypoxia, and eutrophication occur in waters where excessive nutrient loads are present, resulting in the production of cyanotoxins, which threaten aquatic life in the lake. This study couples tributary and open lake sampling with HydroCycle-PO4 sensors in order to determine the source of nutrient loads for Chautauqua Lake. The dominant bloom-forming algae in summertime are the cyanobacteria *Gleotrichia* and *Microcystis*, the latter genus responsible for producing the toxin microcystin. At this point in the study, we have observed that the majority of the phosphorus

loading arises from the lake sediments, with a few tributaries contributing significant loading as well. This project that will locate sources of nutrients in order to inform future mitigation efforts and testing the efficacy of the HydroCycle-PO4 sensors will benefit future studies conducted in western Lake Erie.

A.G. DeMeyer, Y. Wu, M. Venier, Indiana University, Bloomington, O'Neill School of Public and Environmental Affairs; A. Salamova, Indiana University, O'Neill School of Public and Environmental Affairs. **Per- and polyfluoroalkyl substances (PFASs) in the Great Lakes atmosphere and precipitation**.

Several decades of large-scale production and widespread applications have caused PFASs to become ubiquitous in the environment. Due to public concern over the potential adverse health effects induced by PFASs, an increasing number of studies have been conducted to explore their environmental occurrence and associated toxic effects. However, data on PFAS levels in the atmosphere and precipitation remain scarce, particularly in the Great Lakes basin, where 10% of the U.S. population and 30% of the Canadian population reside. A total of 38 per- and polyfluoroalkyl substances were measured using liquid chromatographic tandem mass spectrometry in the air and precipitation at six sites in the North American Great Lakes basin as part of the EPA-funded Great Lakes Integrated Atmospheric Deposition Network project. The target compounds included 13 perfluoroalkyl carboxylic acids, 10 perfluoroalkyl sulfonic acids, 3 fluoroalkyl sulfonamides, 2 fluoroalkyl sulfonamidoethanols, 3 telomer acids, 4 telomer alcohols, and 3 telomer sulfonic acid. Our research provides a systematic insight into the atmospheric PFAS concentrations over the Great Lakes basin.

D.N. Demro, SUNY College of Environmental Science and Forestry, Department of Environmental Sciences; V.A. Luzadis, A. Feldpausch-Parker, SUNY College of Environmental Science and Forestry, Department of Environmental Studies. **CREEQ: Linking public perceptions to biochemical indicators of stream water quality**.

The application of citizen science (CS) in formal research has become increasingly utilized by professionals and can be highly valuable in stream conservation against recurring nutrient over-enrichment. Achieving accurate monitoring of stream water quality (WQ) statewide to maintain protected uses is extremely resource-intensive. Sponsored by the NYSDEC, a research team at SUNY-ESF has applied this participatory approach to supplement the existing network of stream monitoring performed by the agency. This poster presentation outlines the theory, methods, and results of the Citizen Recreational Evaluation of Environmental Quality (CREEQ) initiative. Through an online survey, the CREEQ initiative asks CS volunteers to perform an evaluation of WQ and recreational usability of streams. In response, the research team performed survey validation and sample collection. Samples were analyzed for biochemical WQ-indicating parameters to relate volunteer observations to traditional measures. Validating this relationship and approach will enable the use of CS data to inform stream monitoring efforts across NY.

P.A. Den Uyl, Cooperative Institute for Great Lakes Research, University of Michigan, CIGLR; C.M. Godwin, University of Michigan, Cooperative Institute for Great Lakes Research; S. Harrison, Cooperative Institute for Great Lakes Research, University of Michigan, CIGLR; M.D. Rowe, H.A. Vanderploeg, NOAA GLERL. **Comparative Analysis of Microcystis Buoyancy in Western Lake Erie and Saginaw Bay of Lake Huron**.

Microcystis is the predominant genus of harmful cyanobacterium in both Lake Erie and Saginaw Bay, Lake Huron and is able to regulate its buoyancy and vertical position in the water column, with implications for remote sensing and harmful algal bloom models. We measured *Microcystis* colony buoyant velocity (terminal velocity in a quiescent water column) and size under different intensities

of sunlight to examine variables controlling buoyancy. A majority of colonies in Lake Erie were positively buoyant, while most colonies in Saginaw Bay were negatively buoyant. Lake Erie colonies became less buoyant with increased light exposure. In both lakes, apparent colony density was more variable among small colonies (200 um), causing buoyant velocities to be weakly correlated with colony size, contrary to some previous studies and model assumptions. Decreased variance in the density of larger colonies may be explained by the observation that large colonies tend to have more water-filled voids.

G. Depper, V. Brown, S. Francescon, J. Ashby, Indiana University Bloomington; D. Henshel, Indiana University, School of Public and Environmental Affairs. **Identifying community and household vulnerability to storm impacts and climate stressors**.

Rarely does work in the Great Lakes examine vulnerability and resilience together at household and community levels. This study seeks to identify community and household vulnerability to storm and climate stressors to develop resilience guidance for community members. Based on a vulnerability framework from the 2007 Intergovernmental Panel on Climate Change and a review of resilience and vulnerability indices, an online survey was developed. The survey captures vulnerability, including the degree of sensitivity and adaptive capacity to storm and climate events based on existing infrastructure. The survey will be sent to a list of federal, state, regional, county, nonprofit, academic, indigenous, and immigrant stakeholders, through emails, listservs, newsletters, and social media to reach household representatives in IL, IN, MI, MN, OH, and WI. We will analyze and share the storm and climate infrastructural vulnerabilities of respondents against demographics.

Y.B. Dibike, R.R. Shrestha, C. Spence, B. Bonsal, Environment and Climate Change Canada, Watershed Hydrology and Ecology Research Division. **Impacts of Beneficial Management Practices on Nutrient Loading in a North American Prairie Watershed**.

The water quality of Lake Winnipeg in Canada is experiencing an increasing level of eutrophication, leading to severe algal blooms that are linked to the increased influx of nutrients from the contributing watersheds. Using the Soil and Water Assessment Tool (SWAT), a hydrologic and nutrient transport model of the Assiniboine River basin, one of the contributing watersheds to Lake Winnipeg, was developed to assess the potential impacts of beneficial management practices (BMPs) on nitrogen and phosphorus loading in the basin. Model parameters were optimized using observed data on streamflow and nutrient flux at several stations over the 1990-2009 period. Various BMP scenarios, such as cover-crop, filter strips, reduction in fertilizer application, and no-tillage, were simulated over the 1976-2005 period to see their relative effectiveness in reducing nutrient loading. Preliminary results show that, of the different BMP scenarios, the filter strip resulted in the most significant reduction in nutrient loading.

A.M. DiCarlo, University of Windsor, Great Lakes Inst. for Env. Research (GLIER); C.G. Weisener, K.G. Drouillard, University of Windsor, Great Lakes Institute for Environmental Research. **The influence of microbial community on sediment equilibrium phosphorus concentration (EPC0)**.

Lake Erie phosphorus (P) loadings from nonpoint sources account for 88 to 93% of inputs to the lake. Non-point P loads to small tributaries from agricultural fields are partially altered by a sediment buffering mechanism that governs phosphorus sorption. The equilibrium P concentration (EPC_0) is commonly used to characterize sediment retention capacity. EPC_0 can be used with measures of soluble reactive P to provide a potential sink/source status. EPC_0 is typically measured on field collected sediments *via* batch equilibrium techniques. This study examined the influence of microbial communities on EPC_0. Sediments were sourced from Big Creek, Belle River and Nissouri

Creek. Each sediment was then divided into two fractions: 1) unmodified; and 2) sterilized by gamma radiation. The fractions were used in batch experiments across a range of temperatures. It was shown that both magnitude and direction of shift in EPC_0 differed between sediment types, fractions and temperatures.

G.J. Dick, T. Furnholm, D.J. Smith, R. Hein, University of Michigan, Earth and Environmental Sciences; V.J. Denef, M.B. Duhaime, University of Michigan, Ecology and Evolutionary Biology; S. Chaganti, University of Michigan, Cooperative Institute for Great Lakes Research (CIGLR); R.M. Errera, NOAA; C.M. Godwin, University of Michigan, Cooperative Institute for Great Lakes Research; R.J. Newton, University of Wisconsin-Milwaukee, School of Freshwater Sciences; C. Sheik, University of Minnesota Duluth, Biology and Large Lakes Observatory; D.D. Heath, University of Windsor, 7Great Lakes Institute for Environmental Research; H.A. Vanderploeg, NOAA GLERL. **A Next Generation Research Database to Harness Great Lakes Environmental 'Omics Data**.

Omics approaches provide new ways of monitoring and understanding aquatic ecosystems by sampling biomolecules (DNA, RNA, protein, metabolites) directly from water or sediment samples. Vast quantities of 'omics and associated environmental data are now streaming from studies of the Great Lakes, ranging from random sequencing of microbial communities to targeted detection of specific animal species. However, methods of storing and analyzing these data are limited. To fill this gap, we are building a database and a computational framework for studying complex relationships within and between 'omics data, environmental data, and biological data (*e.g.*, physiological, phenotypic data). This research database will have a user-friendly public web interface, allowing queries of the database both by experts as well as inexperienced users. In order to design an interface that will be useful and accessible to a wide range of scientists and water quality professionals, we seek to engage the Great Lakes research community to identify desired capabilities, standards for data and metadata, and best practices.

C.E. Dumoulin, University of Georgia, Georgia Cooperative Fish and Wildlife Research Unit, Warnell School of Forestry and Natural Resources; S. Tank, Great Lakes Commission; T.R. Tucker, U.S. Geological Survey, Great Lakes Science Center; T. Gruninger, K. Ferran, U.S. Geological Survey; C.T. Moore, U.S. Geological Survey, Georgia Cooperative Fish and Wildlife Research Unit Assistant Unit; K.P. Kowalski, U.S. Geological Survey, Great Lakes Science Center. **Reproducible quality control of multi-input, participant-reported Phragmites management data**.

The *Phragmites* Adaptive Management Framework (PAMF) is a participatory, regional initiative that reduces uncertainty in *Phragmites australis*management outcomes and provides annual guidance to practitioners based on the data they submit. This process relies on several input streams that may contain erroneous, contradictory, or ambiguous information. We discuss PAMF's approach to data quality enforcement, with emphases on issues whose resolution cannot be automated, and procedures to record all changes in a way that enables reproducible analyses. Cases requiring human judgement include the interpretation of 'notes' fields and the determination of whether stem count zeroes and missing values are spurious. We demonstrate our use of a graphical interface to facilitate the resolution of these issues and describe the extent to which spurious zeroes affect the model's learning and guidance outcomes. Lastly, we share lessons learned over three years of PAMF implementation.

A.T. Duncan, Chippewas of Nawash Unceded First Nation #27, Fisheries. **Ciscoes, Indigenous ecological knowledge, and the Saugeen Ojibway Nation**.

The ciscoes (*Coregonus*spp.) of Lake Huron are a poorly understood group of fish that have experienced declines in population numbers and a collapse of their ecological communities. Ciscoes

are culturally and socio-economically important to the people of the Saugeen Ojibway Nation (SON), who have harvested them for food and commerce for generations. A community-based and two-eyed seeing investigation into SON fish harvesters' Indigenous ecological knowledge (IEK) was conducted to address concerns about the cisco fishery.

E

E. Eberhard, Michigan Technological University, Department of Biological Sciences; A.M. Marcarelli, Michigan Technological University, Biological Sciences. **Heterogeneity of nutrient cycling across wetland-stream-lake interfaces of Lakes Superior and Huron**.

Wetland–stream–lake interfaces are characterized by spatial heterogeneity that may facilitate the co-occurrence of biogeochemical processes that are favored under incompatible environmental conditions. We measured rates of N fixation and denitrification, along with nutrient limitation in 15 locations along 5 wetland-stream-lake interfaces in Lakes Superior and Huron. In streams and lakes, N fixation occurred primarily on macrophytes, while in wetlands, N fixation occurred primarily in sediment. In all three habitats, denitrification occurred exclusively in sediments. Nutrient limitation determined using nutrient diffusing substrates did not clearly explain where these two processes occurred across the study sites. Understanding how nutrient limitation and nutrient cycling process rates are interrelated is vital for understanding how these interfaces may respond to coastal nutrient loading.

A.K. Elgin, NOAA Great Lakes Environmental Research Laboratory, Lake Michigan Field Station; G. Carter, Cooperative Institute for Great Lakes Research; P. Glyshaw, NOAA Great Lakes Environmental Research Laboratory; M. Wensman, Cooperative Institute for Great Lakes Research. **Lake Erie quagga mussel growth estimates and evidence of barriers to local population growth**.

Invasive zebra and quagga mussels have been present in the Great Lakes for three decades and have caused substantial change. Environmental factors that influence mussel growth and population dynamics warrant more study, particularly for the more dominant quagga mussel. We conducted a five-month field experiment in western Lake Erie (WLE) to measure quagga mussel growth at two sites with different conditions using mussels contained in cages on instrumented moorings. We also tracked mussels that colonized into the cages. Growth rates were similar despite different chlorophyll *a* levels and notable differences in the density and size distribution of mussels found in the sediments at these sites. The growth rates were approximately 0.03 mm/d for 12-mm mussels and these rates declined with increasing initial shell length. Ultimately, the results from this study provide useful mussel growth parameters and indicate substrate or other limitations for dreissenid mussels in WLE.

L.H. Elliott, University of Minnesota, Forest Resources; P. Landisch, University of Minnestoa, Forest Resources; W. Severud, University of Minnesota; M. Nelson, US Forest Service; J. Vogeler, Colorado State University; J. Knight, University of Minnesota, Remote Sensing and Geospatial Analysis Laboratory. **The role of spatial watershed characteristics in determining brook trout distribution**.

Spatial characteristics of watersheds are important drivers of aquatic species distribution in rivers and streams. We assessed patterns and proximity of land use, land cover, tree canopy cover, impervious surfaces, and protection status across all US Great Lakes watersheds at multiple spatial scales. We obtained spatial data from the 2016 National Land Cover Database, the Forest Inventory and Analysis database, the Protected Areas Database of the United States, and the Riparian Buffer

Delineation Model. We demonstrate the utility of these metrics with machine-learning algorithms modeling brook trout (*Salvelinus fontinalis*) occupancy in Minnesota. Land cover within riparian areas was particularly important to brook trout occupancy. Our models also identified historic stocking as the single best predictor of occupancy, despite often coinciding with human development. These spatial considerations will guide prioritization of subwatersheds for restoration and barrier removal.

R.M. Errera, NOAA; J. Birch, MBARI; G.J. Doucette, NOAA; K. Goodwin, NOAA - AOML; D. Gossiaux, D. Palladino, NOAA GLERL; C. Preston, MBARI; C. Mikulski, NOAA; S. Ruberg, NOAA GLERL; B. Ussler, MBARI. **Establishing a near real-time phycotoxin monitoring network in Lake Erie**.

Cyanobacteria HABs (cHABs) have been a recurrent feature in the Great Lakes since the mid-1990s. These expansive blooms often produce toxin concentrations exceeding health organizations' recommended limits, thus posing a significant threat to ecosystems and human health. Rapid and reliable measurements of toxins are needed to provide researchers, drinking and recreational water managers, and the public with timely, actionable information. We established a monitoring network using the Environmental Sample Processor (ESP), a submersible, autonomous molecular diagnostic device capable of providing near real-time data on toxic algal populations using DNA- and protein probe-based methods. We will discuss the monitoring network within Lake Erie's western basin using both moored and mobile ESPs. Successes and pitfalls of establishing a Great Lakes phycotoxin monitoring network within Lake Erie will be presented, including analytical methods, system platforms, data streams, and communications.

P.C. Esselman, U.S. Geological Survey; L. Brinks, Great Lakes Observing System, Data Management; B. Krumwiede, CSS Inc on contract at NOAA Office for Coastal Management, Great Lakes Office; T. Kearns, Great Lakes Observing System, Data Management; K. Gouws, A. Chappell, NOAA. **Conducting a Needs Assessment for the Great Lakes**.

The biological layer of the lakefloor can have a dramatic effect on ecosystem management. Yet only a tiny fraction of the Great Lakes bathymetry and corresponding habitats have been mapped for high-resolution. Having access to these foundational datasets will improve decision making on ecosystem management, human health, cultural resources, and more. Mapping the Great Lakes in such detail will take considerable time and resources, requiring careful prioritization of where to map first. With support from the GLRI, the Bottom Mapping Working Group (BMWG) partnered with the IWG-OCM to assess regional needs for improved bathymetry, lakebed habitat, and other indispensable data. Leveraging a participatory GIS developed by NCCOS, the BMWG was able to assess priorities for mapping in the US and Canadian waters of the Great Lakes. Through engagement with ~60 contributors and organizations, these results will assist the BMWG in working with partners to help build a future plan for mapping.

P.T. Euclide, University of Wisconsin Milwaukee, Department of Biology; B. Dixon, University of Waterloo; M. Faust, Ohio Department of Natural Resources, Division of Wildlife; L. Miller, Minnesota Department of Natural Resources; K.T. Scribner, Dept. Fisheries and Wildlife, Michigan State; W. Stott, Michigan State Unviersity CESU; C.C. Wilson, ON Ministry of Natural Resources and Forestry, Trent University, Aquatic Research and Monitoring Section; W. Larson, U.S. Geological Survey. **Drift, stocking, and local adaptation determine walleye reproductive connectivity**.

Walleye *Sander vitreus* move large distances during their lifetime and may become harvested far from natal sites. Yet 70 - 98% of walleye return to their natal area to spawn. Therefore, walleye in the Great Lakes may be ecologically connected, but reproductively isolated. To understand human and micro-evolutionary forces contributing to reproductive isolation in walleye, we used a 99,636-

marker RAD-capture (Rapture) panel to genotype 1,296 walleye collected from spawning sites throughout the Great Lakes. We describe fine-scale genetic structure among 31 walleye spawning populations, including within and among Lake Erie's three sub-basins. Admixture between stocked and resident walleye shows how historic stocking events altered natural patterns of connectivity in Nipigon and Black Bay, Lake Superior, and Saginaw Bay, Lake Huron. Finally, we investigated the role of local adaptation in population divergence and searched for regions of the genome showing evidence of selection. Results demonstrate how both ecological (individual movements) and reproductive (gene flow) connectivity should be considered when establishing regulatory units.

R. Eveleth, Oberlin College; J.D. Chaffin, K. Stanislawczyk, Stone Laboratory, Ohio State University; E. Goodell, P. Zimmerman, A. Kirchgraber, L. Poole, Oberlin College. **Lake Erie biogeochemistry in a low-ice winter**.

Little is known about Lake Erie carbon, oxygen, and nutrient dynamics in the winter, however the processes in this season set the stage for summer concerns like harmful algal blooms and hypoxia. In the winter of 2020, a pump off the dock at Stone Laboratory on South Bass Island continuously supplied flow-through water for sonde meaurements and discrete sampling of a suite of biogeochemical parameters. In addition, we continuously measured the metabolic balance of the water column using an Equilibrator Inlet Mass Spectrometer. We observed net heterotrophy and the lake acting as a source of CO_2 to the atmosphere, but also substantial sub-weekly variability. While the lack of stable ice likely prevented the formation of a strong diatom bloom, chlorophyll ranged from 0.71 - 9.6 ug/L. High winds and fleeting ice formation appear tied to nutrient resuspension events that recharge the system. This anomalously low ice year may be indicative of future conditions in a warming climate.

F

M.A. Fabrice, Catholic University of Bukavu (UCB), Centre des Recherches en Environnement et Géo -Ressources; J.W. Riziki, Institut Supérieur Pédagogique de Bukavu, Unité d'Enseignement et de Recherche en Hydrobiologie Appliquée (UERHA); M. Dusabe, Rwanda Wildlife, BP Kigali, Rwanda, Bat Conservation; G.L. Alunga, Institut Supérieur Pédagogique de Bukavu, Unité d'Enseignement et de Recherche en Hydrobiologie Appliquée (UERHA) & Centre de Recherche Universitaire du Kivu; A.B. Kankonda, University of Kisangani, Department of Hydrobiology and Aquaculture, Biology; C. Albrecht, Justus Liebig University Giessen, Department of Animal Ecology and Systematics; J. Eisenberg, Goethe University Frankfurt, Institute of Physical Geography. **River Ruzizi: Integrating hydropower production, ecological integrity and sustainable land use**.

An increasing high demand for freshwater resources and hydroelectricity is one of the greatest modern day global challenges. Hydropower dams often negatively affect the ecological integrity of rivers and compromise the sustainability of their intended development purposes. This study evaluated the minimum hydrological flows and land management constraints required to cope both energy production and river ecological integrity for River Ruzizi, outflow of Lake Kivu, East Africa. The Gumbel's hydrological distribution model was used to perform the flood frequency analysis. The minimum hydrological flow was derived from a power-discharge linear regression model. Results showed that a flow of 28 m^3/s (either 25% of the total river flow) can always be observed outside the turbines for ecological integrity. Turbidity and total suspended solids were highly correlated to rainfall. This work highlights the importance of implementing sustainable soil conservation techniques in the river catchment.

G.L. Fahnenstiel, Michigan Tech Research Institute; M.J. Sayers, K. Bosse, R. Shuchman, Michigan Technological University, Michigan Tech Research Institute. **Carbon Fixation Trends in eleven of the World's Largest Lakes: 2003-2018**.

Large lakes provide immense value to the surrounding populations, yet there is limited understanding of how these lakes will respond to climate change. This study uses remote sensing to estimate annual primary production in 11 of the world's largest lakes from 2003-2018. Lakes include the Laurentian Great Lakes, the African Great Lakes, Lake Baikal, and Great Bear and Great Slave Lakes. Mean annual lake production ranged from under 200 $mgC/m^2/day$ to over 1100 $mgC/m^2/day$, and the lakes were placed into one of three distinct groups (oligotrophic, mesotrophic, or eutrophic) based on their level of production. Analysis revealed three lakes with significant production trends over the study period, with increases in Great Bear Lake (24% increase over the study period) and Great Slave Lake (27%) and a decline in Lake Tanganyika (-16%). These changes appear to be related to climate change, including increasing temperatures and solar radiation and decreasing wind speeds. This study is the first to use consistent methodology to study production in the world's largest lakes, allowing for novel between-lake comparisons and assessment of inter-annual trends.

N.W. Falk, K.G. Drouillard, C.G. Weisener, University of Windsor, Great Lakes Institute for Environmental Research. **In situ Biogeochemical Controls on Suspended and Bed Sediment Phosphorus Buffering in Southern Ontario Headwaters**.

Despite frameworks to reduce nonpoint phosphorus loads to the lower Great Lakes, eutrophication and hypoxia are still ecological and aesthetic impairments. Headwater bed and suspended sediments can be potential vectors of legacy phosphorous (P) release from agricultural catchments but may be difficult to assess. Focused studies on in situ sediment P dynamics within watersheds of concern can add information to existing loading models of soluble reactive, particulate, and total P. This study monitored bioavailable P-release from bed and suspended sediments from three watercourses in southern Ontario throughout 2018 to 2020, with each location representative of the prevailing agricultural practice of the catchment; inorganic fertilizer amendment, organic/manure fertilizer amendment, and a forested reference control. P-desorption potentials were analyzed along with surface water parameters, antecedent weather conditions, and sediment microbial DNA community profiles to identify drivers and indicators of in-situ P-cycling.

M. Faust, Ohio Department of Natural Resources, Division of Wildlife; C. Vandergoot, Michigan State University, Fisheries and Wildlife; R. Kraus, U.S. Geological Survey; T.O. Brenden, Michigan State University, Department of Fisheries and Wildlife; Y. Zhao, Ontario Ministry of Natural Resources; S.A. Ludsin, Aquatic Ecology Lab, The Ohio State University; J. Robinson, New York Department of Environmental Conservation; A. Cook, Ontario Ministry of Natural Resources and Forestry. **Do discrete spawning stocks contribute differentially to Lake Erie's walleye fisheries?**

Understanding stock composition is critical for sustainable management of mixed-stock fisheries. When natural markers routinely used for stock discrimination fail, alternative techniques are required. We used acoustic telemetry to estimate spawning population contributions to commercial and recreational walleye *Sander vitreus* fisheries in Lake Erie. Specifically, we tagged 616 walleye from western basin fisheries during 2017-2019 and monitored spawning locations in subsequent years for presence-absence of tagged fish. Walleye tagged in the commercial and recreational fisheries were detected at each of the four main spawning locations in the western basin, although the number of walleye detected varied among locations and differed between fisheries, but was consistent among years. Our results provide insight into the spawning stock composition of

walleye fisheries in Lake Erie's western basin and suggested that a single spawning stock contributed most of the fish harvested, with other spawning stocks contributing lesser amounts.

C.M. Febria, University of Windsor, Great Lakes Inst. for Env. Research (GLIER) & Dept. of Integrative Biology. **Committing to reconciliation and accelerating ecosystem restoration through #KindnessInScience & Allyship**.

As we enter the UN Decade of Restoration and reflect on mounting evidence of a global biodiversity decline, the need to connect land, water and people has never been more urgent. Moreover, the social contract with scientific research is being reconsidered and expanded to reconciliation with Indigenous communities in research and resource management. For non-Indigenous scientists also committed to both ecosystem restoration and reconciliation, partnerships, knowledge co-production and equitable, ethical and impactful approaches to science are essential. The Healthy Headwaters Lab (University of Windsor, Canada) has taken a systems-thinking approach informed by parallel efforts in Aotearoa New Zealand. Here I offer perspectives on how investments in partnerships and the strategic allocation of resources offer a more effective approach. Outcomes beyond science outputs include capacity- and capability-building, the fostering of richer research environments, and progress towards reconciliation. The key investment is time, but it is essential for ensuring the recovery of the Great Lakes ecosystem for the benefit of future generations.

J. Ferguson, Environment and Climate Change Canada. **Factors contributing to recent extreme water levels and challenges from a water management perspective**.

In recent years, water levels of the Great Lakes have rapidly transitioned from extreme lows to extreme highs. The recent record-high water levels and flows have impacted individuals and organizations throughout the entire Great Lakes - St. Lawrence River system and have challenged the International Joint Commission and its Boards responsible for managing the water management structures on the St. Marys and St. Lawrence Rivers. This presentation will review the factors contributing to the recent extreme water levels, and the challenges from a water management perspective. The applicable rules and limits of Lake Superior Regulation Plan 2012 and Lake Ontario Regulation Plan 2014 will be outlined. The Great Lakes - St. Lawrence River Adaptive Management Committee, which acts as a "bridge" informing water management decisions on the latest science and impact assessments, will also be briefly discussed.

B. Fevold, Sole Proprietor, Science and Engineering; C.J. Palmer, E. Benjamin, R. Sutter, J. Schofield, M. Middlebrook, General Dynamics Information Technology; L.J. Blume, USEPA Region 5 Great Lakes National Program Office, Sci. & Quality Assurance Branch (SQAB) , Lab. Services. **Data Management Plan Tools for Ecological Restoration**.

A data management plan (DMP) is essential to ecological restoration and the effective management of high volumes of complex data and other information often acquired from disparate sources. A DMP supports decision making, knowledge building, and problem solving. Here, we present a DMP template designed for use in ecological restoration. Template elements are based on best practices instituted in policies by academic and government sources, and include those necessary to meet USEPA requirements for project-level quality documentation. The order of template elements follows a workflow of a generalized project lifecycle, addressing key topics such as project (or program) description and administration; data acquisition and collection; data organization, storage and security; data processing and analysis; quality assurance; documentation and content standards; preservation and archiving; sharing and reuse; and policy-based legal and ethical requirements. This DMP template supports project planners in their need to create a

comprehensive yet scalable data management plan to meet the needs of their organization and the complexity of their project.

D.G. Fielder, Michigan DNR, Alpena Fisheries Research Station; T. Binder, Michigan State University/GLATOS, Great Lakes Science Center; C. Vandergoot, Michigan State University, Fisheries and Wildlife; C.C. Krueger, CSIS, Michigan State University. **Large-scale fish movement affects metrics of management importance as indicated by quantitative stock assessment**.

Management of Saginaw Bay walleye in Lake Huron is informed by a statistical-catch-at-age (SCAA) model providing estimates of abundance, spawning stock biomass, mortality rates, and exploitation rates. 37% of the population spends time in the main basin of Lake Huron and is unavailable to the fishery in the bay. The current SCAA model accounts for that movement. To quantify the effect of the inclusion of the migration information into the model, we constructed a reduced model version that was limited only to the bay harvest and data sources. Significantly different by year were 61% of population size estimates, 25% of total annual mortality estimates, 18% of recreational exploitation rates, and 52% of spawning stock biomass estimates. Differences between the two models were greatest in years of high walleye abundance and retrospective analysis indicated that this departure was not an estimation artifact. Generally, the reduced model underestimated predicted abundance. We concluded that incorporation of knowledge of movement of Saginaw Bay walleye from the acoustic telemetry study resulted in better informed stock assessment estimates.

S. Figary, Cornell University, Natural Resources; K. Holeck, Cornell University, Natrual Resources; J.M. Watkins, L. Rudstam, Cornell University, Natural Resources. **Comparing Lake Ontario's nearshore and offshore zooplankton communities using long term datasets**.

Long-term monitoring by GLNPO-EPA of the offshore zooplankton community composition in Lake Ontario found that from 1997 - 2016 the zooplankton community shifted from being dominated by cyclopoids to now calanoids. Lake Ontario also includes nearshore habitat that may be ecologically distinct from the offshore and may have a different zooplankton community composition and abundance due to increased human impacts, earlier spring warming and thermal stratification, and a mixed thermal layer that can include the benthic zone and therefore potentially higher dreissenid mussel effects. Using data from existing datasets, this project will determine if the community shifts observed offshore also has occurred in the nearshore habitat, if the nearshore zooplankton community is more variable than the offshore community, and if that increased variability is linked to other parameters, such as distance from shore, distance from major tributary, or timing of onset of stratification between years.

J.L. Fischer, J. Chiotti, J.C. Boase, U.S. Fish and Wildlife Service; R. Drouin, Ontario Ministry of Natural Resources; E.F. Roseman, USGS-Great Lakes Science Center, Great Lakes Science Center; T. Wills, Michigan Department of Natural Resources. **Setting Measurable Objectives: Determining Ability to Detect Changes in Fish CPUE through Simulation**.

Measurable objectives are foundational to management of natural resources because they allow tracking of progress towards management goals. Measurable objectives must be accompanied by sampling designs that measure appropriate indicators with enough statistical power to detect realistic changes. To determine if a fish monitoring program was capable of detecting system-wide catch-per-unit-effort (CPUE) changes in response to fish spawning habitat restoration, we conducted a simulation study evaluating the probability of detecting six levels of CPUE change over varying levels of sampling effort. Hierarchical models assuming exchangeability across species and locations were used to estimate CPUE differences. The proportion of times a response was correctly estimated was calculated to determine the ability to detect CPUE changes. Results will be used to

guide sampling designs, develop objectives for future restoration projects, and improve a long-term monitoring program.

M.A. Fitzpatrick, M. Munawar, H.A. Niblock, Fisheries and Oceans Canada, Great Lakes Laboratory for Fisheries and Aquatic Sciences. **A long term (> 40 years) analysis of algal blooms in the Bay of Quinte, Lake Ontario**.

The Bay of Quinte is a shallow, riverine embayment in northeastern Lake Ontario with a long history of cultural eutrophication. Phosphorus controls were introduced in 1978 and P loadings have declined from >200 kg/d in the 1970s to Aulacoseira). A further 58 were cyanobacteria (mostly filamentous *Dolichospermum*), however only 4 of these were colonial *Microcystis*. The remaining blooms were mixtures of various taxa. This presentation will explore the taxonomic diversity of algal blooms and discuss the implications for management programs based on over 40 years of data.

K.B. Fitzpatrick, Cornell University, Department of Natural Resources and the Environment; M. Connerton, NYS DEC; M. Yuille, Ontario Ministry of Natural Resources, Lake Ontario Management Unit; N. Therkildsen, S.A. Sethi, Cornell University, Department of Natural Resources and the Environment. **Minimizing cost and uncertainty: assessing marking techniques to distinguish stocked and wild fish**.

Mass marking stocked fish can be used to estimate the relative contribution of wild recruitment to fish stocks, providing data useful for population assessment and informing management decisions. However, the cost of high-quality marking techniques may prohibit implementation, while less costly techniques have higher error rates. Given limited resources for fisheries monitoring, the cost of mass marking must be justified by corresponding improvements in population assessment and management. Using a combination of simulation and empirical estimation, we conducted a cost-benefit analysis of marking techniques to distinguish stocked from wild fish. We first assessed the accuracy rates of each technique, then compared implementation costs against accuracy gains in stock assessment using the Lake Ontario Chinook Salmon fishery as a test case. We found that mass marking could improve stock assessment accuracy, though techniques varied in cost and potential to provide additional information.

C. Foley, Illinois-Indiana Sea Grant; C. Riseng, University of Michigan, SEAS; J. White, Lake Champlain Sea Grant. **Incorporating Justice, Equity, Diversity, and Inclusion into Research and Fellowship Competitions**.

Scientists are reflecting on how to effectively incorporate justice, equity, diversity, and inclusion (JEDI) values in their work. Funding agencies who support research and fellowship experiences for faculty, post-docs, and students are no exception. While organizations such as NSF and NOAA are trying to be more equitable in how they distribute awards, it seems unlikely that there will be a one-size-fits-all solution to this systemic issue. The Great Lakes Sea Grant programs have worked with their colleagues across the nation to develop a series of options for funding organizations that wish to improve their JEDI efforts. Some strategies currently underway include sensibly striving for equitable representation among reviewers and review panels; encouraging research that will benefit underserved communities; and revising review criteria and/or instructions for reviewers to explicitly consider who is being supported and how they engage with underserved groups and individuals. The authors will share resources for those who wish to explore these options, and will welcome an opportunity to discuss how they can continue to improve their efforts in this arena.

M.E. Fraker, University of Michigan, Cooperative Institute for Great Lakes Research (CIGLR); J.S. Sinclair, Aquatic Ecology Lab, The Ohio State University, EEOB; K.T. Frank, Queen's University;

J.M. Hood, S.A. Ludsin, Aquatic Ecology Lab, The Ohio State University. **Contrasting states of the Lake Erie ecosystem and their implications for ecosystem-based management**.

We compiled long-term monitoring data on multiple biological, physical, chemical, and economic components of the Lake Erie ecosystem, then explored ecosystem trends and drivers within three time intervals (1969-2018, 1984-2019, and 1999-2019) using four indicator groups: species abundances for zooplankton, fishes, and birds, as well as derived metrics of the forage fish community. Concurrent temporal shifts of individual variables were observed, but asynchronous dynamics also were evident among taxa. The rank orders of predictive drivers shifted among the three time intervals, but drivers related to lake trophic status were consistently strong predictors and physical drivers tended to increase in predictive power within shorter time intervals. The variation in driver rankings across time intervals may reflect differences between drivers that determine long-term patterns by setting limits on the potential range of an indicator compared to drivers that influence interannual variation.

J. Fredrickson, J.A. Austin, University of Minnesota, Duluth, Large Lakes Observatory. **Spatial Scales and Gradients during Radiatively Driven Convection in Lake Superior**.

A stationary mooring with horizontal resolution was deployed in Lake Superior in spring and early summer of 2019 to study radiatively driven convection (RDC). During this period, cool surface water warms and increases in density, sinking and circulating throughout the water column. Thermistor data from the mooring shows clear evidence of warm cells propagating laterally during daytime hours, and this temperature variability is typically dominated by advection. During periods of current along the mooring orientation, total advection rates are condensed to one term and calculated. Advection rates and local time rates of change are found to be roughly equal in magnitude (on the order of +/- 0.0001-0.0002 ?C/s), suggesting that the temperature time rate of change following a moving parcel is approximately 0 ?C/s and justifying a "frozen field" assumption to allow for 2D temperature resolution and estimation of convective cell features.

L.M. Fry, T. Hunter, J. Kessler, NOAA, Great Lakes Environmental Research Laboratory. **Implications of surface observation network on historical estimates of net basin supply**.

Predicting impacts of future climate on Great Lakes coasts requires understanding past changes in hydrometeorology. The NOAA GLERL Great Lakes Hydrometeorological Database has historically provided the most comprehensive dataset for representing the net basin supply (NBS) components over time across the entire basin. Recently, this database has been used to advance state-of-the-art estimates of NBS components, either as input to statistical approaches or as a benchmark for comparison. The Hydromet Database relies on Thiessen interpolation of surface observations from the Global Historical Climatology Network and the Intergrated Surface Database. The long-standing assumption was that all stations be used for interpolation, with some basic QA/QC procedures applied first. This presentation will describe efforts to more rigorously evaluate the station network used to provide the Hydromet database historical estimates of NBS components and share updated estimates of these components.

G

J.A. Garcia, R. Brouwer, University of Waterloo, Department of Economics; R. Pinto, University of Waterloo, Department of Earth and Environmental Sciences. **Estimating Total Economic Costs of Nutrient Emission Reduction Policies to Halt Eutrophication in the Great Lakes**.

The Great Lakes (GL) in North America are among the largest freshwater resources on this planet facing serious eutrophication problems as a result of excessive nutrient loadings due to

population and economic growth. New policies to reduce pollution are often ill-informed due to the lack of integrated models or methods that provide decision-makers insight into the direct and indirect economic impacts of their policies. This study fills this knowledge gap and estimates the impacts of different total phosphorus (TP) restriction policy scenarios across the GL. A multi-regional hydro-economic model is built and extended to include TP-emissions from point and non-point sources. The results show decision-makers the least cost-way to achieve TP-emission reduction targets. Reducing TP-emissions by 40% in all GL amounts to a total annual cost of three billion Canadian dollars or 0.15% of Canada's GDP. The cost structure changes substantially as policy targets become more stringent, increasing the share of indirect costs, affecting not only the economic activities around the GL, but the economy of Canada as a whole due to the tightly interwoven economic structure.

A. Alamanos, The Water Forum; J. Garcia-Hernandez, University of Waterloo, Department of Economics. **Balancing Phosphorus runoff reduction and farmers' utility: An optimization for Lake Erie Area**.

Ontario' Action Plans consider and apply several strategies to improve water quality. Reducing phosphorus (P) runoff to Lake Erie is the major goal. This work addresses the problem from an optimization perspective that seeks integrated and effective management solutions: A linear profit maximization presented, suggesting an alternative crop distribution in sub-region level, subject to water use and fertilizers constraints. The minimization of P emissions is also examined, to find the necessary social marginal cost to balance the drop in farmers' utility as a result of applying less fertilizers. The results show that rural economy can be more prosperous than current levels, even under strict environmental constraints. The proposed framework is a novel approach for the study area and can provide a basis for future collaborative planning between government and stakeholders, towards economically effective and sustainable management.

G. Gardner, U.S. Environmental Protection Agency, Office of Research and Development. **The Property Value Benefits of Remediating the Ashtabula River Area of Concern**.

The literature contains estimated property value benefits from remediated Areas of Concern (AOC), based on avoided property value losses. However, these studies took place prior to any remediation work, so benefits are *predictions* based on an assumed recovery of losses, which may not occur. This research compares the predicted and realized property value benefits from remediation, using the Ashtabula River AOC as a case study. Predicted remediation benefits range from $21 to 31 million. Post-remediation, however, these benefits are not realized. Rather, results indicate an exacerbated loss of up to $9.7 million. This does not imply a lack of benefits from remediation, only that the benefits as realized through housing values did not take place during the time frame studied. The presentation concludes with a discussion of the implications of these findings for funding organizations in the case study area and other AOCs, including possible actions to improve outcomes.

D.G. Gill, University of Michigan, Cooperative Institute for Great Lakes Research; M.D. Rowe, NOAA GLERL; C. Stow, NOAA Great Lakes Environmental Research Laboratory; C.M. Godwin, University of Michigan, Cooperative Institute for Great Lakes Research; S. Moegling, Cleveland Water. **Co-production of a Lake Erie Hypoxia Forecast with Ohio Public Water Systems**.

This year marks the conclusion of a five year project by NOAA GLERL and CIGLR to co-produce a hypoxia forecast model with public water systems who draw water from Central Lake Erie. Co-production is a process for creating more usable science by conducting research collaboratively with the intended users. With the support of a project advisory group, focus groups and surveys were conducted during the first and final year of the project to identify the decision-

support needs of public water systems while seeking to understand the impacts of hypoxia on plant operations. As a result of these efforts, we increased participant knowledge about Lake Erie hypoxia and produced an experimental hypoxia forecast that increases public water system capacity for an early treatment response. We also developed recommendations to promote forecast usability as it is transitioned to an operational product (including the need for an emailed forecast update to public water systems for accessibility), and identified directions for additional research on the effects of hypoxia on water quality.

C.M. Godwin, University of Michigan, Cooperative Institute for Great Lakes Research; M.D. Rowe, NOAA GLERL; C. Stow, NOAA Great Lakes Environmental Research Laboratory; T.H. Johengen, University of Michigan, Cooperative Institute for Great Lakes Research (CIGLR). **Sediment oxygen demand kinetics in Lake Erie's central basin**.

One impact of eutrophication in Lake Erie is seasonal hypoxia in the central basin, which is caused by sediment oxygen demand (SOD) during stratification. We measured SOD kinetics using cores from different locations, stages of stratification, and temperatures. While previous SOD measurements were reported as zero-order rates associated with specific dissolved oxygen (DO) concentrations, we fitted mixed-order models in which the dependence of SOD on DO varies between zero- and first-order. The rate constant increased with temperature, as expected, but the model order decreased from nearly first-order in the spring to zero-order in the fall. This is consistent with a shift from limitation by diffusion of oxygen during spring, to dependence on the flux of reduced substances or metabolism in the fall. A key implication of these results is that the progression of hypoxia during summer may be slower than in fall, when sediments have recently been hypoxic and DO in the hypolimnion is low.

C. Goltz, Wilfrid Laurier University, Geography; H. Jovanovic, Wilfrid Laurier University; A. Chicoine, University of Saskatchewan; H. Jaeger, H. Key, University of Missouri; N. Casson, University of Winnipeg, Geography; J. Venkiteswaran, Wilfrid Laurier University; H. Baulch, University of Saskatchewan, School of Environment and Sustainability; C. Whitfield, University of Saskatchewan; R.L. North, University of Missouri, School of Natural Resources; E. Kinzinger, University of Missouri. **The Impacts of Nitrogen on Cyanobacterial Harmful Algal Blooms in Eutrophic Water Bodies**.

Cyanobacterial algal blooms are a concern to human health as well as aquatic communities within waterbodies. These blooms are caused by an influx of nutrients, and research suggests that while phosphorus is responsible for biomass accumulation, different forms of nitrogen can play a role in toxin release. The goal of this research is to understand how different forms of nitrogen (nitrate, urea, ammonium) in combination with phosphorus can influence the biomass accumulation and production of the toxin microcystin in small urban lakes. The results of the study demonstrate how different forms of nitrogen have varying effects on the algal biomass. While nitrogen form had no effect on microcystin presence, site was revealed to have a major influence. These results can improve our understanding of nutrient impacts on microcystin, enabling management for control of these toxins.

J.T. Ives, University of Windsor, Great Lakes Institute for Environmental Research; E. Gondwe, MSU Centre for Systems Integration and Sustainability, Department of Fisheries and Wildlife. **Setting small scale fisheries in food and nutrition security themes: Trends in Sub Saharan Africa**.

Fisheries food systems provide important ecosystem services in sub-Saharan Africa (SSA) as a nutritious food source to over 200 million people and offer avenues for countries to attain Sustainable Development Goal (SDG) 2.1. However, there is a dearth of knowledge on fish

pathways to food and nutrition security, especially for inland small-scale fisheries (SSF). We use a literature review to assess how SSF fish food systems in SSA relate to four themes of food security: availability, access, utilization, and stability. We synthesize existing knowledge of the role of inland SSF in food security, and how it varies across the four pillars, political-economic contexts, and gender dimensions. We assess how each of these pillars of food security has been conceptualized and investigated in the literature, identifying important avenues for future research. We make recommendations on research agendas to enhance the sustainable contribution of inland small-scale fisheries to food security.

A. Gouveia, University of Toledo OH, Environmental Sciences; S.S. Qian, University of Toledo, Department of Environmental Sciences; J. Smith, University of Toledo, Environmental Sciences; C.M. Mayer, University of Toledo, Lake Erie Center, Environmental Sciences; J. Bossenbroek, University of Toledo, Environmental Sciences; W. Hintz, University of Toledo, Dept. of Environmental Sciences; R. Mapes, University of Toledo OH, Environmental Sciences; E. Weimer, J. Navarro, DNR, Ohio; R.T. Young, U.S. Fish and Wildlife Service; P. Kocovsky, U.S. Geological Survey; J. Buszkiewicz, DNR, Michigan. **A simple Bayesian method to estimate abundance of rare species: using grass carp as a case study.**

Quantifying fish abundance informs management strategies. However, this can be challenging due to heterogeneity in factors such as the data collection procedures (eg. non-standardized methods, insufficient effort, etc). When limited information is available the choice of the model and its structural assumptions are of critical importance and will influence inference. For instance, N-mixture models commonly used to estimate population abundance underperform with sparse and scarce data. We addressed these problems by developing a simple yet flexible Bayesian model using the grass carp (*Ctenopharyngodon idella*) capture data from the Sandusky River, Ohio as a case study. Preliminary results indicate an approximate abundance of 100 - 200 (95%, 51-160) grass carps per year, suggesting that our modeling approach is ideally suited for providing reliable population estimates in the early stages of an invasive species using data that would be unfeasible with other modeling approaches.

L. Grapentine, D. Milani, Environment and Climate Change Canada, Water Science and Technology Directorate. **Monitoring nearshore sediment conditions in the Great Lakes: Applications to research and management**.

The Laurentian Great Lakes are important economic and ecological resources for humans and other biota inhabiting the region. As hosts to substantial human populations and industrial activities, the Great Lakes are affected by multiple stressors. One of the most pervasive of human impacts is the degradation of sediments. Monitoring physicochemical and biological conditions of sediments is critical to detecting and understanding the causes of their degradation, as well as informing their management and identifying recovery. Here we describe the monitoring since the early 1990s of benthic conditions at 160 nearshore reference locations and 10 areas of degraded sediment. We show how sediment quality was characterized based on multiple endpoints, how reference and degraded site conditions changed over time, and how the endpoint data were applied in a formal sediment management framework. Without consistent long-term monitoring, these analyses would be either less effective or not possible.

A. Grimm, R. Shuchman, M.J. Sayers, R. Sawtell, Michigan Technological University, Michigan Tech Research Institute. **Updating and expanding the Landsat-based submerged aquatic vegetation map for the Great Lakes**.

Using ca. 2018 Landsat OLI imagery, submerged aquatic vegetation (SAV) in the Laurentian Great Lakes was updated using a semi-automated processing and classification method. This new

map expands on the previous ca. 2010 map to include more connecting waterways as well as Lake Superior. A database of recent field observations was assembled with contributions from several partners to assess the accuracy of the new map. The overall map accuracy is 84.2%, on par with the 2010 map. The new map indicates that approx. 21% of the Great Lakes bottom substrate that can be mapped with Landsat-8 is colonized with SAV, varying from approx. 41% in Lake Ontario to 2% in Lake Superior. At the lake scale, our updated maps show little change in percent SAV cover between 2010 and 2018. However, continuing increases in water clarity across much of the Lakes have extended both our mapping limit and the area of suitable habitat for SAV into deeper water, resulting in modest increases in total SAV extent.

R.C. Grow, Lakehead University, Biotechnology; F. Fischer, E. Berglund, Ministry of Natural Resources and Forestry, Fisheries; M.D. Rennie, Lakehead University, Biology. **Estimating Cisco (Coregonus artedi) density in Lake Superior using an up-looking acoustic platform**.

In the Great Lakes, traditional down-looking acoustic surveys have been used to evaluate the status and trends of pelagic fishes. These traditional surveys provide a non-destructive alternative to standard capture-based surveys which can have biases related to gear efficiency and fish density. However, the potential disturbance of fishes by survey ships associated with traditional acoustic surveys introduces its own bias to the survey, and can lead to underestimations of fish density. To combat this bias, we deployed a stationary up-looking acoustic platform (spider) in Lake Superior and compared results with a traditional down-looking survey. Preliminary results from four fall deployments suggest that the spider detected 2.6 times as many Cisco as the traditional survey. Additionally, when the ship passed by the spider, fish density estimates from the spider dropped by 67% on average when compared to the 20 min before and after the ship's arrival; while the ship mean estimates remained constant through this region. Our results suggest that ship avoidance is a major factor of bias to consider in traditional acoustic surveys.

J.T. Ives, University of Windsor, Great Lakes Institute for Environmental Research; S. Gubamwoyo, National Water and Sewerage Corporation. **Phytoplankton and macroinvertebrates dynamics in the Murchison Bay**.

Pollution levels in L. Victoria are rising to alarming levels, thus incurring more water treatment costs. Ecosystem health is a very important aspect in determining the eutrophic status of the lake. Major indicators of ecosystem health are the physio-chemical characteristics, phytoplankton and macroinvertebrate species. These indicators have both spatial and temporal variations. An ongoing ecosystem health study of Murchison Bay began in 2020. The most common phytoplankton identified in the highly polluted areas were Cyanobacteria while the relatively polluted areas had diatoms. This study began with phytoplankton species identification and will expand to include phytoplankton species quantification and macroinvertebrate species identification and quantification. Murchison Bay is located in the Northern part of L. Victoria, which receives partially treated runoff and wastewater from Kampala. The findings will inform management decisions on catchment management and pollution control.

H

J.S. HALAFO, IIP-Fisheries Research Institute of Mozambique; C. Jonasse, IIP-Fisheries Research Institute of Mozambique, Assessment of Fishes. **Seasonal Variations of usipa (Engraulicypris Sardella) Fishery in the Mozambican Portion of Lake Niassa**.

The seasonal variations in the fishery of usipa are evaluated for the period between July 2000 and June 2007, and in the period after the partial Reserve of Lake Niassa has been declared in 2011

by the Government of Mozambique. The data were collected in 6 fishing strata established by the Fisheries Research Institute for the sampling of artisanal fisheries. The average monthly CPUE recorded between 2000 and 2007 for the beach seine and chirimila fishing gears was 22.16 kg and 24.84 kg respectively. The highest CPUE occurred in July for the beach seine gear and September for chirimila gear. 61.4% of usipa total catches came from the district of Lake were the partial Reserve is located. About 76.4% of these catches came from the dry season period. Two fishing stratas located in the southern part of the lake, showed the highest catches. Interesting to see is that, after the reserve was declared in 2011, the fishing effort and catches of usipa increased, giving an indication that this fishery remains sustainable under the effort that is subjected.

S.T. Haller, R. Su, A. Lad, J.D. Breidenbach, D.J. Kennedy, The University of Toledo College of Medicine and Life Sciences. **HABs Toxin Microcystin-LR Exposure Exacerbates Pre-existing Inflammatory Bowel Disease**.

Inflammatory bowel disease (IBD) is characterized by acute and chronic inflammation of the gastrointestinal (GI) tract. IBD's multifactorial etiology includes genetic and environmental factors. Environmental factors have been studied in IBD, however, not microcystin-LR (MC-LR). MC-LR is a toxin produced by freshwater cyanobacteria around the world. MC-LR has been well established as a liver toxin but it has not been well studied for effects in the intestines. The goal of this study was to investigate MC-LR toxicity within healthy models and models of pre-existing IBD. Experimental mice were split into four exposure groups: 1) control, 2) IBD, 3) oral exposure to MC-LR, 4) pre-existing IBD+MC-LR. The IBD model demonstrated colonic ulceration and increased inflammation. MC-LR in the setting of pre-existing IBD caused severe toxicity and exacerbated increases in inflammation. Results suggest MC-LR has minimal toxicity in healthy settings but significant pre-existing IBD toxicity.

A. Hannes, US Army Corps of Engineers. **Beneficial use of dredge material restores wetland habitat in the upper Niagara River**.

Sediment remediation programs in the Great Lakes, like the Great Lakes Legacy Act, have succeeded in removing contaminated legacy sediments, which are often located outside or under navigation channels. These programs have improved overall sediment quality, and the need for confined disposal facility placement no longer exists at some harbors. Further environmental regulations enacted by federal, state, and local agencies have reduced the influx of new pollution into waterways. Therefore, sediments in harbors and rivers around the Great Lakes are becoming cleaner and can now be used for beneficial purposes like habitat restoration and creation, beach nourishment, and aquaculture. In this project, clean dredged sediments from the Buffalo River Federal Navigation Channel were used to create and restore ten acres of wetland habitat at Unity Island, a riverine island in the upper Niagara River.

S.E. Hansen, B.C. Cahill, Central Michigan University, Earth and Ecosystem Science; R.A. Hackett, M.J. Monfils, Michigan State University, Michigan Natural Features Inventory; A.K. Monfils, Central Michigan University, Department of Biology and Institute for Great Lakes Research. **Aggregated occurrence data informs management of invasive European frog-bit**.

Aggregated observation-based and specimen-based occurrence datasets are emerging resources for the conservation and management of Great Lakes invasive species. Herein, we present a case study of 10,987 unique occurrence records of European frog-bit (EFB) obtained from over 100 U.S. and Canadian data providers. Historical specimen data were critical for documenting the spatial and temporal progression of EFB invasion. Community-derived data, e.g. iNaturalist and the Midwest Invasive Species Information Network, facilitated real-time Early Detection Early Response. Focused monitoring efforts provided site-specific high resolution data to inform local management

decisions. The aggregated dataset captures the spatiotemporal extent of EFB's invasive range, informing EFB species distribution models, an expanded invasion risk assessment, and the development of a decision support tool for targeted EFB management.

H.L. Harrison, University of Guelph, Geography, Environment, and Geomatics; P.A. Loring, University of Guelph, Arrell Food Institute and the Department of Geography. **Seeing beneath disputes: reading the stories in natural resource conflict**.

Conservation conflicts are pressing social and environmental sustainability issues, and their complex underlying dynamics can be difficult to understand. Appropriate tools are needed for breaking down complex conservation conflicts into their varied parts so that they may be understood and managed. Importantly, these tools must transcend disciplinary silos, so as to be applicable across social science disciplines as well as within and outside of the academic context. In this presentation, we discuss the importance of looking for the stories beneath the disputes—asking specifically how conflicts fit in to long-standing narratives about rights, visions, and values. This entails exploring differences in ways of knowing and recognizing that conflicts themselves are often understood in very different ways by the various parties involved. Given that stakeholder disputes can seriously undermine conservation efforts, the framework we present pushes forward practical understandings of conservation conflict interventions by offering a novel, transdisciplinary tool for better understanding their complex, multifaceted variables.

A.M. Harrison, Central Michigan University, Institute for Great Lakes Research; D.G. Uzarski, Central Michigan University, Institute of Great Lakes Research, CMUBS, and Department of Biology. **Using long-term monitoring data to evaluate impacts of Great Lakes water levels on coastal wetlands**.

Coastal wetlands of the Laurentian Great Lakes are biodiverse ecosystems that support critical habitats and provide ecosystem services for the region. These wetlands are influenced by lake processes, and within the last decade, the Great Lakes experienced extreme low (2012, 2013) and extreme high (2017, 2019, 2020) water levels. As fluctuations and variation in water levels can affect nutrient cycling, our objectives are to assess influences of lake water levels on coastal wetland nutrients. We combined water chemistry from the Coastal Wetland Monitoring Program with publicly available Great Lakes water level data from 2011 to 2019 for approximately 150 wetlands each year. Coastal wetland depths follow annual trends in Great Lakes water levels in each lake, but variation from year to year is less extreme in the wetlands. Wetland depth is an important predictor for nutrient chemistry (total N and P) in coastal wetlands, though site specific factors (e.g., land cover, vegetation) are also important. By quantifying impacts of water levels on coastal wetlands, we can better understand how their ecosystem services are altered under variable hydrologic conditions.

J.H. Hartig, University of Windsor, Great Lakes Institute for Environmental Research; S. Franccoeur, Eastern Michigan University; J.J. Ciborowski, University of Calgary, Biological Sciences; J.E. Gannon, formerly of the International Joint Commission; C. Sanders, Essex Region Conservation Authority; P. Galvao-Ferreira, University of Windsor; C. Knauss, G. Gell, University of Michigan; K. Berk, Dalhousie University. **Checkup: Assessing Ecosystem Health of the Detroit River and Western Lake Erie**.

The State of the Strait Conference is a biennial forum that assesses ecosystem status and provides advice to improve research, monitoring, and management of the Detroit River and western Lake Erie. Although there has been considerable improvement in the Detroit River since the 1960s, much additional cleanup is needed to restore ecosystem health. Western Lake Erie is now at risk of crossing several potential tipping points caused by the interactions of a variety of drivers and their stresses. This assessment identified eight ecosystem challenges: climate change; eutrophication and

harmful algal blooms; toxic substance contamination; invasive species; habitat loss/degradation; nonpoint source pollution; human health/environmental justice; and population growth/transportation expansion/land use changes. It also found that investments in monitoring and evaluation are insufficient, the region's intellectual and environmental capital is not being leveraged sufficiently to address current challenges, and continued investment in this transnational network is essential to support ecosystem-based management.

T. Hayden, Michigan State University/GLATOS; D.G. Fielder, Michigan DNR, Alpena Fisheries Research Station; B. Dorr, US Department of Agriculture, Wildlife Services, National Wildlife Research Center. **Windows of opportunity: Telemetry reveals optimal time periods for stocking**.

Walleye and Double-crested Cormorants are migratory predators that undergo extensive movements associated with spawning and nesting in Lake Huron. Understanding the spatial and temporal extent of predator movements in Lake Huron has bearing on fish stocking locations and timing to reduce predation on stocked fish and maximize survival. We used acoustic telemetry data of Saginaw Bay walleyes (some of which out-migrate to the main basin of Lake Huron) and satellite telemetry of cormorants (returning to nesting grounds from the south) to estimate arrival dates of migratory predators at stocking ports in Lake Huron. Peak arrival dates for walleye ranged from April 29 in the south to May 2 in the north. Cormorants begin arriving earlier, but peak dates were from April 21 to April 26. These results suggest hatchery-reared fish should be released before these dates to maximize survival. If cormorant hazing at stocking sites can be sustained, then the walleye arrival dates become the principal deadline for releases.

X. He, C. Tomasallo, J. Meiman, Wisconsin Department of Health Services. **Wisconsinites' fish consumption and fish advisory awareness: analysis of 2017-2019 Wisconsin BRFSS**.

To better understand Wisconsinites' fish consumption and fish advisory awareness, we analyzed responses from the 2017-2019 WI BRFSS fish module (n=15,757). In the past month, 90% of adults reported eating fish (mean 4.2 fish meals/month). About 21% ate sportfish, of whom 77% were aware of WI fish advisories. Only 41% of fish consumers ate the recommended 1-2 fish meals/week, half ate less than 1 meal/week, and 3% ate more than 3 meals/week. Adults aged 45-64 years and adults with college education were twice as likely to eat 1-2 fish meals/week than those aged 18-24 years and those with less than high school education. Milwaukee county adults were 3 times more likely to eat more than 3 fish meals/week than other WI adults. Compared to white adults, black adults were 70% less aware of advisories and ate 10% less fish. Most adults did not eat enough fish to reap nutritional benefits. Further public education is required to maximize health benefits and minimize the risks of eating fish.

P. Helm, Ontario Ministry of the Environment, Conservation and Parks, Environmental Monitoring & Reporting Branch. **Levels, sources, and fate of microplastics in the Great Lakes / St. Lawrence River - A review**.

Microplastics and plastic debris are found in all five Great Lakes, their tributaries, and the St. Lawrence River. Drawing from >35 peer-reviewed publications, this review highlights the sources, concentration trends, and fate of microplastics within the Great Lakes basin. Microplastic levels are elevated near urban centers where rivers, stormwater and municipal wastewater deliver plastics to the lakes. Models show how winds and currents distribute plastic across the lakes, and sediment studies suggest lake sediments are microplastic repositories. Fragments and fibers generally dominant microplastic particle types found. The shape and character of both microplastics and macroplastic debris help provide source indicators to guide control initiatives. Although the aquatic environment is now better characterized, little information is available on levels and impacts of

microplastics in Great Lakes biota and in air. Remaining challenges and future directions are discussed.

H. Henderson, CIGLR, University of Michigan, Observing Systems & Advanced Technologies; T.H. Johengen, University of Michigan, Cooperative Institute for Great Lakes Research (CIGLR); S. Ruberg, NOAA GLERL; R. Miller, University of Michigan, Cooperative Institute for Great Lakes Research (CIGLR). **Monitoring harmful algal bloom driving dynamics in western Lake Erie using nutrient sensor moorings**.

Distribution and cycling of nitrogen and phosphorus in western Lake Erie, as mediated by hydrologic and hydrodynamic forces, is stochastic and therefore cannot be easily predicted. Large and highly variable changes in external loading sources and internal nutrient cycling may influence the timing, severity, and duration of phytoplankton blooms, including toxic cyanobacteria, and thus has significant implications for regional stakeholders. In this study, data from two real-time continuous water quality monitoring buoys deployed in western Lake Erie were used to examine fine scale nutrient dynamics, including wind-driven resuspension of highly bioavailable phosphorus. Significant correlation between sensor and laboratory data prove the reliability of these in-situ nutrient sensors and the value of continuous monitoring platforms in dynamic environments within regions of public health pertinence (e.g. drinking water, recreation).

D. Henshel, Indiana University, School of Public and Environmental Affairs; J. Ashby, V. Brown, G. Depper, Indiana University Bloomington. **Using GIS to Identify Community-Based Critical Infrastructure Weaknesses to Storm-Induced Flooding**.

Climate change is increasing in intensity and frequency of storm activity in the Great Lakes watershed, leading to increases in storm-related flooding. During and following storm-induced flood events, communities must be self-reliant as government-organized help takes hours to days to reach all flood-affected regions. At the community level, flood impact can be viewed from the perspective of community-focused critical infrastructure – the infrastructure that supports community well-being, modified from DHS-CISA critical infrastructures considered from a community needs perspective. GIS analysis of the intersections between indicators of community-based critical infrastructure and FEMA flood zones highlights areas of the Great Lakes watershed at greatest risk for adverse community impacts. Quantifying the overlap between indicators of flooding and vulnerability for community critical infrastructure within a normalized area allows for semi-quantitative assignment of vulnerability metrics.

S. Henson, J.D. Ortiz, Kent State University, Dept. of Geology. **Remote Sensing Monitoring of Lake Okeechobee Harmful Algal Blooms Using the KSU VPCA Method**.

Lake Okeechobee, Florida regularly experiences HABs that impact the environmental, economic and recreational aspects of the state. Although many remote sensing approaches detect cyanobacteria, the KSU Spectral Decomposition Method uses a VPCA approach to separate one mixed signal into multiple independent in-water constituents. This method was developed to effectively identify multiple water constituents such as phylum level Cyanobacteria, Chlorophyta, Bacillariophyta and Ochrophyta, as well as constituents of HABs, CDOM and sediment within water bodies. This 2019 case study of Lake Okeechobee using Sentinel-3A/B OLCI is presented to document the versatility of the KSU VPCA method. Using water quality data provided by the South Florida Water Management District, 25 satellite images were processed using the KSU VPCA Method and compared to in-situ data, and high significance was found between the component loadings and corresponding measurements. It is apparent that better monitoring techniques lead to better management practices, and our goal is that this method will trailblaze the path to better water management practices globally.

M.B. Herzog, Cleveland Water Alliance. **Smart Citizen Science: Empowering Lake Erie Communities with Technology and Data**.

Engagement of citizen science (volunteer monitoring by non-expert residents) represents an important opportunity to expand limited regional data collection capacity across Lake Erie communities. Residents feel a powerful sense of connection to and responsibility for their water resources and are often willing to contribute their resources and time to that end. Local organizations have been harnessing this energy to power volunteer groups that monitor local water quality in communities across the region for years. However, these *citizen science* groups have typically developed in response to hyper-local management needs, resulting in a fragmented regional landscape of Lake Erie Citizen Science that approaches data collection, management, and use protocols on a watershed-by-watershed basis. Cleveland Water Alliance (CWA) seeks to address these challenges through the development of the *Smart Citizen Science Initiative* - a network that coordinates volunteer monitoring groups across the Lake Erie basin and serves as a testbed for piloting new community monitoring technologies.

S. Hickel, D.R. Pearsall, G.M. Annis, The Nature Conservancy, Conservation Science; K.F. Robinson, The Nature Conservancy Michigan Chapter, Conservation Science; M. Liberati, Michigan State University, Department of Fisheries and Wildlife; M. Jurjonas, The Nature Conservancy, Bailey Conservation Fellow. **Restoring coastal wetlands to benefit people: Enhanced patterns from the Blue Accounting Database**.

The Nature Conservancy strives to create a virtuous cycle where conserving nature improves human well-being and people recognize nature's ability to enhance their quality of life leading to better outcomes for both people and nature. Blue Accounting, an initiative endorsed by The Nature Conservancy, demonstrates the virtuous cycle taking place in the Great Lakes. The Blue Accounting Great Lakes coastal wetlands project database has recently doubled with the addition of 200+ project records from the U.S. Fish and Wildlife Service, allowing us to re-evaluate patterns related to recognition and promotion of benefits to people resulting from protection, restoration or enhancement of coastal wetlands. As such, these database patterns assess whether Great Lakes coastal wetland projects are promoting human wellbeing benefits and if that promotion of human wellbeing is making a difference within Great Lakes communities.

J.S. Higley, EQO, Inc. **Environmental RNA for Remote, Non-Disruptive, Identification and Population Activity Analyses**.

Recent advancements in the preservation of environmental RNA (eRNA) has opened new and exciting opportunities for the analysis of invasive and native species in aquatic ecosystems. Where eDNA allows for an increased ability to perform risk management and track broad trends in populations of interest, eRNA, which breaks down quickly in the environment, can be utilized to determine which genes are being transcribed at the time of collection. Questions like: Is there a currently living population present? Is the population about to spawn or actively spawning? Is the population responding to stress? and more are able to be answered. In this presentation, we will show applications of this technology in invasive species management and look ahead to new projects being explored for inter- and intra-species transcriptomic analyses for better ecosystem management.

C. Hill, University of Minnesota Duluth, Mechanical and Industrial Engineering. **WITHDRAWN: Developing low-cost, open-source observation systems for expanding Great Lakes observation seasons**.

Widespread availability of low-cost, open-source sensors and data acquisition platforms provide opportunities to expand the density of marine observation systems. Developing systems that

require less infrastructure to deploy also increases the possibility for expanding monitoring locations. This talk will look at ongoing development of a low-cost, open-source platform for Lagrangian (or moored) measurements across the Great Lakes from a program aimed at engaging University students in developing new observation platforms and ongoing Great Lakes monitoring efforts. Of particular interest is engineering a system capable of deployments immediately prior to late-season storms to provide real-time measurements when many observation platforms have been recovered for the winter. Increasing observation capabilities during these challenging seasons could enhance numerical model development, add further insight into satellite observations, and provide potential for new studies into large freshwater system air-sea interactions, contaminant transport, extreme waves, ice tracking, and other mobile observations.

E. Ho, S.C. Courtenay, University of Waterloo, School of Environment, Resources and Sustainability; Z. Ding, University of Waterloo, Biology; A.J. Trant, University of Waterloo, School of Environment, Resources and Sustainability. **Monitoring for cumulative effects assessment (Cladophora) in the Grand River and Lake Erie**.

We explore how cumulative effects assessment (CEA) may be integrated in freshwater monitoring. Context for implementation is provided using a Canadian case study of *Cladophora* in Lake Erie's eastern basin. We propose a new framework for freshwater monitoring to operationalize cumulative effects, incorporate co-creative approaches with diverse stakeholders/rightsholders, and connect monitoring to decisions being made. We consider practitioner definitions of CEA, criteria for selecting indicators, recommendations, and implications. CEA is characterized using replicated principles and conclusions from more than 25 years of literature and practice. We suggest collaborative systems thinking methodologies (e.g., systems mapping) should be formally incorporated into CEA practice. Although this study was undertaken with the Grand River and eastern Lake Erie in mind, our results and discussion represent broader experiences that may be useful if developing monitoring for CEA elsewhere.

J.C. Hoffman, US EPA, Great Lakes Toxicology and Ecology Division; S. Janssen, D. Krabbenhoft, USGS Mercury Research Lab; G. Peterson, US EPA Office of Research and Development; R. Lepak, University of Wisconsin-Madison, Aquatic Sciences Center; M. Pearson, US EPA Office of Research and Development; A. Cotter, US EPA Office of Research and Development, ORD/CCTE/GLTED. **Tracing mercury sources through a Great Lakes coastal wetland food web using a multi-stable isotope approach**.

In the Great Lakes, an important management goal is to address fish consumption advisories by remediating mercury-contaminated sediments and restoring aquatic habitat. However, routine monitoring in fish tissue has proven difficult because mercury concentrations can vary widely in coastal ecosystems. We hypothesize that differences in habitat use and life history, and potentially mercury source, will affect mercury bioaccumulation. Therefore, we used a combination of carbon (C), nitrogen (N), and mercury (Hg) stable isotope analysis (SIA) in aquatic invertebrates and prey fish to reconstruct diet, trophic level, and mercury source in an impacted coastal wetland food web. Both invertebrates and prey fish had C and N isotopic compositions that indicated location- and species-specific differences in energy pathways. Associated Hg SIA revealed small-scale differences in Hg sources (industrial versus watershed) in the food web. The small-scale variation reveals an opportunity to use a multi-isotope approach to quantify the effect of habitat restoration on source-specific mercury bioaccumulation.

C.M. Holbrook, USGS Great Lakes Science Center, Hammond Bay Biological Station; M.J. Hansen, USGS, Hammond Bay Biological Station; N.S. Johnson, USGS, Great Lakes Sci Center, Hammond Bay Biological Station; S. Miehls, USGS, Great Lakes Science Center, Hammond Bay Biological

Station; G. Bravener, Fisheries and Oceans Canada, Sea Lamprey Control Centre; J. Barber, U.S. Fish and Wildlife Service. **Use of Lake Erie tributaries by spawning sea lamprey: Implications for lake-wide abundance estimates**.

Accurate estimation of lake-wide abundance of sea lampreys would provide an objective evaluation of control-program effectiveness. However, previous attempts to estimate the number of sea lampreys in a lake using coded-wire-tags were believed to be biased because key assumptions were violated. For example, an assumption that marked and unmarked individuals are equally likely to be captured during recapture sampling would be violated if individuals were non-randomly distributed within the lake, exhibited non-random spawning stream selection, or if capture or tagging reduced survival of marked individuals. We used acoustic telemetry to test those assumptions by tagging sea lampreys during two life stages and tracked their movements among 23 Lake Erie tributaries. Stream selection differed among release location and life stages, but also among lake regions, suggesting that lake-wide abundance may be attainable with some knowledge of the distribution and dynamics of the target population.

T.J. Holda, Cornell Biological Field Station; L. Rudstam, J.M. Watkins, Cornell University, Natural Resources; S. Pothoven, NOAA Great Lakes Environmental Research Lab; D. Warner, USGS; T. O'Brien, Great Lakes Science Center; K. Bowen, Fisheries and Oceans Canada; W.J. Currie, Fisheries and Oceans Canada, Great Lakes Laboratory for Fisheries and Aquatic Sciences; B. O'Malley, USGS Great Lakes Science Center; P. Boynton, Cornell Biological Field Station, Department of Natural Resources; D.J. Jude, University of Michigan, Natural Resources.
Comparing mysid abundance and trends across the five Great Lakes.

Mysis diluviana is the largest zooplankter in the Great Lakes and an important prey for offshore benthic and pelagic fishes. In the past 50 years, major ecosystem changes have occurred in several of the Great Lakes (oligotrophication, loss of *Diporeia,* increased mussels) that could affect mysids. We analyzed mysid data from the 1990s through 2019 from several sampling programs to detect time trends and compare mysid abundances across the five Great Lakes. We found that lakes Ontario and Superior *Mysis* abundance have been relatively stable since 1997 – in contrast to declines in lakes Michigan and Huron. Mysid abundance trends are correlated with productivity indices derived from chlorophyll and zooplankton biomass, indicating that declines may be attributed to oligotrophication. Low mysid abundance in the deeper waters of eastern Lake Erie is not consistent with the productivity gradient and suggests predatory control of mysids by abundant rainbow smelt in that basin.

F. Holm, R. Berardo, The Ohio State University, School of Environment and Natural Resources; S. Alexander, University of Waterloo, Faculty of Environment. **WITHDRAWN: Assessing the Complex Governance of Aquatic Invasive Species in the Great Lakes**.

Managing Aquatic Invasive Species (AIS) depends not only on biological and economic issues but also on coordination and cooperation involving multiple stakeholders. To date, however, there is limited understanding of AIS governance at the Great Lakes level. We address this issue by studying collaboration and coordination patterns among stakeholders involved in AIS management across the lakes. We present the results of a stakeholder survey released in 2020, and comparatively analyze the governance networks for Asian carps, sea lamprey, and round goby. Our main goal is to analyze how the network of relationships between stakeholders involved in AIS management affects the likelihood of finding solutions to invasions. We proceed under the assumption that comparative case studies across different invasive species are needed to fully understand how complex governance systems face wicked environmental problems. This project has the potential to shape our knowledge of complex fresh-water governance systems as well as discover meaningful policy implications for the development of invasive species regulations, policies, and partnerships.

M. Holtgren, Encompass Socio-ecological Consulting. **WITHDRAWN: Multi-cultural strategies for equitable collaboration**.

Over the past five decades the rights of indigenous people have been recognized and reaffirmed across the Great Lakes region. This has placed people with different knowledge systems side-by-side to collaborate on natural resources decisions making, research projects, and data analysis. Accordingly, Indigenous and Western Knowledge types have either expected to be compatible or indigenous people encouraged to embrace the use of Western Knowledge. A new paradigm has been developing where both knowledge systems are valued, differences are recognized and embraced, and shared values found. This presentation will showcase multi-cultural fishery partnerships in Michigan that have found space for both Indigenous and Western values to flourish while promoting learning-by-doing strategies. Each of the case studies will be presented to demonstrate the challenges faced, strategies used, and key steps to developing a successful relationship.

Y. Hong, University of Michigan, Cooperative Institute for Great Lakes Research (CIGLR); E.J. Anderson, J. Kessler, L.M. Fry, NOAA, Great Lakes Environmental Research Laboratory. **Towards improved coastal flood modeling for the Great Lakes**.

Coastal flood hazard in the Great Lakes region is becoming more frequent in recent years, causing catastrophic property damages and loss of lives. Storm surge models developed for this region significantly advanced in recent years, but they still fail to predict patterns of coastal flooding with sufficient accuracy. To address this knowledge gap, this study makes use of a state-of-the-art numerical modeling system, with improved mesh grids and model configurations. Four different modeling setups are evaluated: (i) mesh-grids for lake surface, modeling of storm surge processes; (ii) mesh-grids for lake surface, modeling of storm surge and wave propagation processes; (iii) mesh-grids extended to land areas, modeling of storm surge processes; and (iv) mesh-grids extended to land areas, modeling of storm surge and wave propagation processes. Simulated water-level is compared with gauge observations for assessing the accuracy of different model settings. Moreover, simulated flooding areas are inter-compared and discussed.

E. Houghton, NEW Water Green Bay Metropolitan Sewerage District, Watershed Department. **Compliance in the watershed: Working outside the treatment plant**.

NEW Water, the brand of the Green Bay Metropolitan Sewerage District, is made up of two wastewater treatment facilities serving greater Green Bay in northeast Wisconsin. Through an innovative approach, NEW Water is utilizing an Adaptive Management (AM) compliance option offered through the Department of Natural Resources as a new way to meet future total phosphorus and total suspended solids limits dictated in discharge permits for the facilities. The NEW Watershed AM compliance program is working with interested land owners in two sub-watersheds of the lower Fox River to identify resource concerns, prioritize best management practices, and implement projects specifically designed to reduce excess phosphorus and sediment from polluting local waterways. This approach was tested in a pilot study conducted from 2014 – 2020. The AM compliance approach has the advantage of reducing the same amount of pollutant load to the lower Fox River system for less money than building costly tertiary treatment at the wastewater treatment facilities, while providing a larger ecological impact to the impaired sub-watersheds in the NEW Water service area.

E.T. Howell, ONT Ministry of the Environment, Conservation and Parks, Environmental Monitoring and Reporting Branch. **Parry Sound, an Embayment Complex of Georgian Bay Protected from Dreissenid Mussels**.

Water quality of embayments of the Parry Sound Region of eastern Georgian Bay contrast with the nearshore of the lake. The Big Sound, maximum depth of 105 m, connects with others varying in water exchange with the Big Sound. Nutrient and major ions levels are shaped by drainage from the Canadian Shield which loads soft and moderately phosphorus-rich water contrasting with exchange with Georgian Bay which delivers hard and low-phosphorus water. Inter-embayment mixing results in gradients across embayments. Productivity indicators suggest oligotrophic to mesotrophic conditions among embayments. Total phosphorus and chlorophyll measured in 2016 suggest little change from earlier studies. Calcium levels in 2016 were below 15 mg/L, a threshold in other areas of Georgian Bay below which dreissenid mussels were usually absent. The presentation examines the hypothesis that the embayments of Parry Sound provide a productive refuge from the ultra-oligotrophic nearshore of Georgian Bay.

A.R. Hrycik, L.E. Burlakova, A.Y. Karatayev, SUNY Buffalo State College, Great Lakes Center; S.E. Daniel, SUNY Buffalo State, Great Lakes Center. **Biomass Estimates for Benthic Invertebrates of the Great Lakes**.

Biomass estimates of individual species are crucial for many applications, including food web modeling, understanding trophic tracers such as stable isotopes, and estimating ecosystem services. However, data for benthic invertebrates in lakes can be difficult to find and individual weights within species may be ecosystem-specific. We calculated individual wet weights for over 100 species of benthic invertebrates in the Great Lakes using an eight-year data set. Results are presented by species and by major taxonomic groups. Furthermore, we tested for significant differences in benthic invertebrate weights between lakes, depth zones, and basins and made recommendations of instances in which weights can be generalized across ecosystems or should be kept separate.

H. Hu, University of Michigan, Ann Arbor, Cooperative Institute for Great Lakes Research; A. Fujisaki-Manome, CIGLR, University of Michigan; P. Chu, NOAA, Great Lakes Environmental Research Laboratory. **Simulating Great Lakes wave conditions with one-way coupled hydrodynamic-wave models**.

The large surface areas and the prevailing wind directions in the Great Lakes result in long fetches that can lead to the development of high waves. Accurate wave forecasting is critical for navigation, fishing, beach uses, and the coastal industry. The Great Lakes Wave Unstructured Model at NOAA provides forecast guidance of wave conditions in the Great Lakes using the WaveWatchIII (WW3). While the model performance has been well verified, there is known underestimation of peak significant wave height (SWH) under high winds. We hypothesize that the issue is due to the underestimation of wind forcing or/and lack of hydrodynamics, particularly water level and surface current in the WW3 configuration. In this study, hourly elevation and currents from the Finite Volume Community Ocean Model results were integrated into WW3. The root mean square errors and absolute errors for simulated SWH against buoy observations indicated that the model improved by about 10 % during 2019 simulations.

Y. Huang, R. Brouwer, University of Waterloo, Department of Economics; H. Liu, Tourism Saskatchewan. **Economic costs of eutrophication in the Great Lakes Basin: a preliminary study**.

Cultural eutrophication degrades freshwater quality and alters aquatic ecosystem services and structure. The lack of a comprehensive study about the economic costs of eutrophication in the entire Great Lakes Basin motivated us to estimate the costs based on a wide range of case studies in the existing literature. The estimation suggests an aggregate annual cost of roughly $100 million - $7 billion for Canada and $3 billion - $31 billion for the US. In terms of different impact categories, in Canada, about 80% of the costs are attributed to the losses of lakefront property values. In the US,

half of the costs are associated with the property values, and 40% are associated with water treatment. In both countries, the smallest portion of the total costs is on human health care. Further investigations by lake show that those most severely afflicted by eutrophication are Lake Ontario followed by Lake Erie in Canada and Lake Michigan followed by Lake Erie in the US.

A. Huff, J. Zalusky, S. Katsev, T. Ozersky, University of Minnesota-Duluth, Large Lakes Observatory. **Environmental variability and nutrient cycling by deep-water quagga mussels in the upper Great Lakes**.

Since their introduction in the late 1980s, zebra and quagga (dreissenid) mussels have dramatically altered benthic community structure and nutrient dynamics in the Laurentian Great Lakes. To date, few studies have quantified deep-water quagga mussel bioenergetics and physiology. We investigated how nutrient excretion and respiration rates of dreissenids in Lakes Michigan and Huron vary under differing environmental conditions. Samples were collected from 20m to 130m deep sites, and shipboard incubations were used to quantify rates of mussel respiration and N and P excretion. Dreissenid excretion and respiration rates varied with depth, season and sampling location. Field data was used to parameterize a dynamic energy budget model simulating deep-water dreissenids bioenergetics. We show that deep-water dreissenid excretion and respiration rates are predictable and can be modeled in response to varying environmental conditions to better inform whole-lake nutrient budgets.

I

L.K. Idraikh, CCTRONIC. **Actively controlling Runoff through Data collection**.

cHorizon is a solution made to resolve Lake Erie's most pressing issue: Algae Blooms caused by the overload of nutrients from the surrounding farmlands. Our solution works at the source of the problem by collecting data from the farms to help mitigate the amount of nutrients that seep through the soil into the waterways and, eventually, to the Lake's water. Stationed at the farm side collecting data through an array of sensors. The collected data is specific to the amount of nutrients that is currently in the soil, keeping tabs on the levels and giving a clearer picture of when the nutrient supply needs to be replenished and when it is within normal levels, in addition to monitoring other variables and act accordingly to maintain balance in the field and reduce unnecessarily losses and pollution. All collected data is stored in a cloud periodically and is processed and analyzed using several machine learning algorithms in order to automate actions, provide better insights for decisions and help in projecting future analysis and design better plans to conserve soil and water resource and keep a natural balance

D. Isermann, USGS-Wisconsin Cooperative Fishery Research Unit; T. Binder, Michigan State University/GLATOS, Great Lakes Science Center; D. Dembkowski, Wisconsin Cooperative Fishery Research Unit; T. Hayden, Michigan State University/GLATOS; S. Hansen, Wisconsin Department of Natural Resources; D. Caroffino, Michigan Department of Natural Resources; C.C. Krueger, CSIS, Michigan State University; C. Vandergoot, Michigan State University, Fisheries and Wildlife; W. Larson, USGS-Wisconsin Cooperative Fishery Research Unit. **Telemetry, genomics, and conventional tagging Inform lake whitefish management in northwestern Lake Michigan**.

We used a combination of acoustic telemetry, conventional tagging, and genetics to evaluate movements and stock structure of lake whitefish spawning at four different locations in northwestern Lake Michigan: the Fox and Menominee Rivers, Big Bay de Noc, and along the lakeside of the Door Peninsula near North and Moonlight Bays. Preliminary analyses indicate: 1) few lake whitefish tagged on the lakeside of the Door Peninsula enter Green Bay; 2) lake whitefish

tagged in the Fox River typically do not venture north of Chambers Island; 3) lake whitefish tagged in Big Bay de Noc rarely go south of Chambers Island but do leave the Bay; 4) approximately two thirds of the lake whitefish tagged in the Menominee River remained south of Chambers Island; and 5) lake whitefish spawning in tributaries to southern Green Bay are part of a genetically distinct stock. Our findings have been used to support changes in harvest management in one management zone and have prompted increased interest in identifying sources of recruitment for lake whitefish in southern Green Bay.

J.T. Ives, University of Windsor, Great Lakes Institute for Environmental Research. **Impact of mixing on seasonal variations of productivity and phytoplankton communities of Lake Edward**.

We conducted monthly sampling from Jan 2017 to Oct 2018 in the pelagic zone of Lake Edward, Uganda to determine seasonal variability in environmental characteristics, and changes in phytoplankton composition and abundance expected from seasonal changes. Phytoplankton abundance was estimated and microscopy was used to identify the dominant taxa. Mixing events were observed in the dry season of 2017 and 2018. In 2017, this had a strong influence on primary production, with chlorophyll a (Chla) up to 20 μg/l in 2017, and cyanobacteria at 10-14 μg Chla/l, diatoms 4-6 μg Chla/l and green algae less than 3 μg Chla/l. A relatively high C:N ratio (~10±1.9) indicated moderate pelagic N limitation. However, in 2018 this influence was unclear, with Chla barely higher than 10 μg/l despite strong complete mixing. A multivariate analysis identified the main environmental variables involved in the success of cyanobacteria and diatoms, broadly confirming the conclusions of previous work in Lake Edward.

J

M. Jabot, SUNY Fredonia. **The integration of youth-led citizen science to hydrologic monitoring**.

This presentation will present the ongoing initiative that integrates K-12 students and teachers in long-term monitoring of water quality. The work described builds on the US Partnership between SUNY Fredonia and the GLOBE Program. This partnership trains teachers in established water quality protocols which are then used by student investigators to collect in-situ data. The analysis of these data is set in the context of the international data sets maintained by the GLOBE Program. Future expansion of this work will be shared as will the expanded use of remotely sensed imagery and geospatial technologies.

A. Jacob, E. Davenport, K. Kimbrough, M. Edwards, E. Johnson, NOAA/National Centers for Coastal Ocean Science. **Contaminant monitoring in the Great Lakes by NOAA's Mussel Watch**.

NOAA's National Centers for Coastal Ocean Science Great Lakes Mussel Watch Program (MWP) has been monitoring in the Great Lakes since 1992 using dreissenid mussels as indicator organisms. Through coordination with Great Lakes Restoration Initiative since 2010, the program expanded its monitoring activities in the region with the objective of providing data and information in making sound science based management solutions for the restoration of Great Lakes. The program incorporated newer approaches and techniques into its traditional chemical monitoring protocol to meet evolving environmental challenges. Under the Great Lakes Action Plan II, MWP initiated monitoring contaminants of emerging concern (CEC) and assessment of the effects of these emerging compounds on mussel health. Under the ongoing Great Lakes Action Plan III, the focus is on chemicals of mutual concern identified in the 2012 Great Lakes Water Quality

Agreement. In this presentation, we will give an overview of the new approaches adopted for monitoring mussels and other matrices, and present results on the extent and magnitude of bioaccumulation and bioeffects of contaminants.

S. Jaffe, The University of Toledo, Department of Environmental Sciences; S.S. Qian, University of Toledo, Department of Environmental Sciences; N. King, University of Toledo, Lake Erie Center; C.M. Mayer, University of Toledo, Lake Erie Center, Environmental Sciences; P. Kocovsky, U.S. Geological Survey. **Predicting the presence of grass carp eggs based on tributary flow and temperature**.

Spawning of the invasive grass carp in a Lake Erie tributary (Sandusky River) was documented in 2015 through targeted egg sampling. Continued eggs sampling in the Sandusky River suggested that grass carp spawning is related to streamflow and water temperature. Using a Bayesian approach, we first established the likelihood of spawning as a function of the two factors. The results show that spawning is most likely to occur with higher flows and medium to low temperatures. Using stream-specific flow (discharge)-velocity relationships, the Sandusky River model results were used as a guide to determine the risk of grass carp spawning in eight other tributaries of Lake Erie. The Maumee River in Ohio and River Raisin in Michigan had the highest risk compared to the Sandusky River. Our model provides a mechanism for setting research and management priorities to develop management strategies aimed at preventing the establishment of a breeding grass carp population in Lake Erie.

J. Janssen, University of Wisconsin-Milwaukee, School of Freshwater Science; D.J. Jude, University of Michigan, Natural Resources. **Not all mud; rocky habitat in deep water in the Great Lakes**.

Deep water in common (-size) lakes generally has a mud bottom accumulated since the glaciers left. But, in the Great Lakes there are deep, meso-oceanic-scale currents that create deepwater erosion and deposition areas. One area of erosion is at the foot of deep reefs and this erosion creates a halo of cobble around reef bases. We propose that this creates unexplored habitat for lithophilic organisms (sculpins, burbot, Hydra) and illustrate this with submersible videos from the 1980s and more recently. We propose that there exists an unidentified archipelago of deep, rocky "islands" that provide shelter, forage, and spawning grounds. For lithophilic organisms these rock patches are oases with the consequence that sampling via gear such as bottom trawls pulled over mud are sampling in a desert.

A. Hagemeyer, University of Minnesota Duluth; D. Jensen, University of Minnesota Sea Grant Program; J. Dumke, Natural Resources Research Institute. **Reporting Underreported Aquatic Invasive Species Sightings in Northeast Minnesota**.

Understanding where aquatic invasive species (AIS) are present is important for knowing their distribution, extent of potential impacts, and management. Across Northeast Minnesota entities such as federal agencies, counties, and lake associations are conducting independent fieldwork for early detection and monitoring of AIS. Some fieldwork may be non-invasive in nature, so AIS sightings can become buried in field notes and never formally reported. These include: banded mystery snail (Viviparus georgianus), Chinese mystery snail (Cipangopaludina chinensis), curly-leaf pondweed (Potamogeton crispus), and rusty crayfish (Faxonius rusticus). We requested citing locations of these AIS from entities in five Northeast Minnesota counties. Spread was far greater than expected with a total of 451 sightings reported, mainly rusty crayfish, Chinese mystery snails, curly-leaf pondweed and banded mystery snails, plus sightings for six other AIS. Sightings were uploaded into the St. Louis County AIS Risk Assessment Tool (https://data.nrri.umn.edu/ais/) and reported to NOAA/GLERL's Great Lakes Aquatic Nonindigenous Species Information System.

T.H. Johengen, H. Anderson, University of Michigan, Cooperative Institute for Great Lakes Research (CIGLR); C.M. Godwin, University of Michigan, Cooperative Institute for Great Lakes Research; S. Ruberg, NOAA GLERL; P.J. Alsip, University of Michigan, Cooperative Institute for Great Lakes Research. **In situ monitoring of sediment phosphorus flux during seasonal hypoxia in the central basin of lake erie**.

Continuous in situ soluble reactive phosphorus (SRP) analyzers were deployed at two sites within the central basin hypolimnion to estimate the onset and rates of sediment SRP flux. Instruments were moored 0.5 m above the sediment along with temperature and dissolved oxygen sensors at one-meter intervals across the thermocline. Final hypolimnetic depths varied from 1.5 to 4 m. Anoxia onset occurred at the sites on Aug 24 and Sept 9. SRP concentrations remained low throughout the hypoxic period and increased abruptly within 12 to 42 hours of anoxia onset. Anoxic flux rates averaged 25.7 and 11.4 $mg/m^2/d$, respectively. A temporary displacement of the anoxic hypolimnion with normoxic water caused an immediate cessation of positive SRP flux suggesting rapid, redox-controlled phosphorus adsorption/desorption. Extrapolations of in situ flux rates over reported scales of anoxia suggest internal SRP loading rates are comparable to annual tributary TP loads to the central basin.

J. Buckley, Ontario Ministry of Natural Resources and Forestry, Glenora Fisheries Station; L.M. Hunt, J.A. Rodgers, Ontario Ministry of Natural Resources and Forestry, Centre for Northern Forest Ecosystem Research; A. Drake, Fisheries and Oceans Canada, Great Lakes Laboratory for Fisheries and Aquatic Sciences; T.B. Johnson, Ontario Ministry of Natural Resources and Forestry, Glenora Fisheries Station. **Assessing Ontario's vulnerability to aquatic invasive species under climate and human population change**.

Uncertainty exists about how climate and human population changes will affect invasion risk from aquatic species. We developed a model to evaluate the vulnerability (arrival, survival, and spread of invasive invertebrates, plants, and fishes) under baseline (2018) and future (2040-2070) conditions in Ontario. The model consists of three components: i) human pathways of propagule delivery, ii) relative suitability of recipient ecosystems for AIS survival, and iii) natural dispersal. The locations of greatest pathway activity were spatially concentrated with an increasingly concentrated pattern in the future. Habitat suitability incorporating climate change should also increase, though not uniformly, and the location and magnitude of increase was less predictable. Combined, the current and future vulnerability of Ontario's landscape to AIS exhibits strong spatial patterning that differs by pathway, indicating that management will require both pathway- and species-specific focus.

R. Johnson, A. Maloy, C. Rees, S. Keppner, M. Bartron, K. Bockrath, A. McGovern, T. Lewis, P. DeHaan, J. Coombs, Fish and Wildlife Service. **Bridging Gaps in Aquatic Invasive Species Early Detection Through International Collaboration**.

The Great Lakes are susceptible to aquatic invasive species (AIS) through canals, international shipping, and other vectors. Early detection of AIS is hindered by the lack of taxonomic keys, difficulty in early life stage identification, and the ability to detect species at low abundance. This project seeks to bridge the gap between AIS known to be a risk to the Great Lakes with the lack of available tools to detect them. Genetic tools such as eDNA offer promise for early detection; however, the application is limited by the scarcity of reference sequences, validated genetic markers and tissue for testing. We identified a list of priority AIS to target for voucher collection and marker development. Voucher specimens collected from international locations with similar climates are used to obtain mitochondrial genome sequences which are released publicly on GenBank. These sequences and tissues are used by FWS genetics labs to develop and validate genetic markers for AIS early detection.

J.T. Johnson, University of Kansas, Geography & Atmospheric Science. **Indigenous Research Sovereignty: Setting a Tribal Agenda for Environmental Research**.

Before we can talk about Indigenous research sovereignty, we should discuss how Indigenous peoples have been impacted by research over the past several centuries. Until recently, tribes have had virtually no say over what research was conducted in their midst. As Linda Tuhiwai Smith asserts in her now famous book, Decolonizing Methodologies, "research is probably one of the dirtiest words in the Indigenous world's vocabulary." That said, tribes do understand the value of research, both from their own epistemological foundations and Western scientific traditions as well. Many tribes have active research teams working for and with them, frequently on environmental topics, but also addressing social science topics as well. The real question is, who controls the research? This paper will address how tribal community research agendas are set, and how these agendas are guided by Indigenous leaders and non-Indigenous researchers alike.

J.J. Josephs, T. Hollenhorst, US EPA, Great Lakes Toxicology and Ecology Division; M. Wick, University of Minnesota Duluth, Water Resource Sciences. **Social Remediation and Restoration in Great Lakes Areas of Concern Communities**.

EPA strives to integrate environmental justice (EJ) and equity through programs, tools and research initiatives to protect marginalized communities from the harmful effects of environmental contamination. Marginalized populations are disproportionately exposed to environmental contaminants, bear inequitable health consequences and are confronted with institutional barriers that inhibit equitable access to resources that enable health, wealth and well-being. Marginalized communities impacted by racism and discrimination may experience trauma. This contributes to a cycle of disparity that influences their capacity to meet human needs, engage in social processes and achieve equitable benefits. We conducted a literature review exploring AOC guidance materials and studies as well as literature about EJ and adverse community experiences and marginalization. We then discuss alternative approaches and a framework as possible bridges between AOCs and whole-community health and well-being.

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D.D. Kane, Heidelberg University, National Center for Water Quality Research, Biology and Environmental Science; N. Manning, National Center for Water Quality Research at Heidelberg University, National Center for Water Quality Research; M. Razzano, Ohio Environmental Protection Agency, Division of Surface Water; L.T. Johnson, Heidelberg University, National Ctr for Water Quality Res., National Center for Water Quality Research. **When It Snows It Pours: Recent Increases in Chloride in Lake Erie Tributaries with a focus on the Cuyahoga River**.

Previous studies in the Midwest and Northeast have shown that amount of chloride in rivers is increasing, is driven by road salt application, and is correlated with the amount of urbanization in a watershed. To test whether this is the case for northern Ohio rivers, we determined chloride trends for the Maumee, Sandusky, and Cuyahoga Rivers using 35+ years of data from the Heidelberg Tributary Loading Program. Mean daily concentrations (mg/L) of chloride increased significantly and substantially over time only in the Cuyahoga River (most urbanized watershed) and although significant increases occurred in all seasons, the greatest increases were in winter. These results point both to the importance of continuous, long-term monitoring and the presence of diffuse, nonpoint source pollution impacting aquatic ecosystems. Finally, our data lend support to the Freshwater Salinization Syndrome, but only in rivers with substantial residential and urban land uses in the watershed.

K.L. Kapuscinski, J. Wesolek, A.H. Moerke, Lake Superior State University, Center for Freshwater Research and Education. **Ecological responses to hand removal of European frog-bit**.

European frog-bit (EFB) is a free-floating plant native to Europe and Asia, but it is a recent invader in Michigan waters. EFB is known to form dense mats and it presumably has adverse effects on native species, but our ecological understanding of EFB in the Great Lakes is in its infancy. The objective of our study was to quantify responses of plants, macroinvertebrates, and fishes to hand removal of EFB in coastal wetlands of the St. Marys River. In summer 2020, we sampled 44 sites (33 with EFB, 11 without) for a suite of environmental variables and assemblages of plants, invertebrates, and fishes. At invaded sites, we either did not remove EFB (n=11), removed it once (n=11), or removed it biweekly (n=11). All sites were resampled biweekly over 8 weeks. Mean percent cover of EFB ranged ~12-26% among invaded sites prior to hand removal. After a single hand removal, mean percent cover of EFB decreased by ~90% and remained below ~3% cover for the next 8 weeks. Biweekly removals only resulted in additional declines of 1-2%, indicating that a single hand removal may be effective at managing EFB. Responses of plants, invertebrates, and fishes to removal of EFB also will be discussed.

A.Y. Karatayev, L.E. Burlakova, A.R. Hrycik, SUNY Buffalo State College, Great Lakes Center. **Benthos of Laurentian Great Lakes: Inventory of lake-wide surveys**.

Over 110 lake-wide (basin-wide) benthic surveys were conducted on the Laurentian Great Lakes. However, these studies often are not readily available, and have never been combined in one dataset to preserve historic data. According to our estimations, primary data for at least 20% of all surveys are incomplete or have already been lost. For over three years the Great Lakes Center has been conducting inventory of benthic surveys for all Great Lakes to create a database with all available information on species composition, distribution, density, and biomass of benthic invertebrates. Considering the rarity of long-term benthic studies in lake ecosystems, these data set could be useful to explore effects of different environmental factors and exotic species on community organization, for monitoring of water quality, biodiversity, exotic species introduction, fish food base assessment, and other ecosystem services provided by benthic community. Our first complete dataset on Lake Ontario benthic community includes taxonomic data to the species level for 11 of the surveys and data to the group level for another two surveys covering the last 54 years.

J. Li, The Hong Kong University of Science and Technology, Department of Ocean Science; V. Ianaiev, University of Minnesota Duluth; A. Huff, J. Zalusky, T. Ozersky, S. Katsev, University of Minnesota-Duluth, Large Lakes Observatory. **Quagga mussels now control the phosphorus cycle in the Great Lakes**.

Invasive bottom-dwelling dreissenid mussels have dramatically reengineered the ecosystems of the Laurentian Great Lakes. Here we show that they have also altered the biogeochemistry of the productivity-limiting nutrient. A single species, the quagga mussel, is now the primary regulator of phosphorus cycling in the lower four Great Lakes. By virtue of their enormous biomass, quagga mussels sequester large quantities of P in their tissues and dramatically intensify benthic P exchanges. Mass balance analysis reveals a previously unrecognized sensitivity of the Great Lakes ecosystem, where P availability is now regulated by the dynamics of mussel populations while the role of the external inputs of phosphorus is suppressed. This qualitatively changes the responses of the affected lakes to phosphorus inputs from watersheds, complicates predictions, and necessitates a new paradigm for managing these large aquatic ecosystems.

M.B. Kayastha, Michigan Technological University, Civil and Environmental Engineering; P. Xue, C. Huang, Michigan Technological University, Civil & Environmental Engineering; X. Ye, Michigan Tech University, Civil Engineering; G.A. Meadows, Michigan Technological University, Great Lakes

Research Center; Z. Miller, USACE, Office of Great Lakes Hydraulics and Hydrology; T. Hunter, L.M. Fry, P. Chu, NOAA, Great Lakes Environmental Research Laboratory. **Projections of Great Lakes' water level based on a 3D regional climate modeling system**.

In this study, projections of net basin supply (NBS), its three components (over-lake precipitation, lake evaporation, and basin runoff), and water levels are made for the mid- and late twenty-first century. Three CMIP5 GCMs were dynamically downscaled using the Great Lakes-Atmosphere Regional Model (GLARM) to predict the changes in NBS. GLARM is a two-way lake-atmosphere coupled three-dimensional (3D) regional climate modeling system with a 3D hydrodynamic lake and ice model, and its use in water level prediction is an improvement over the widely used one-dimensional (1D) lake models. In all the four Great Lakes, depending on the GCM chosen for downscaling, both increases and decreases are predicted for the future NBS and water level. The predicted water level change ranges from -0.091m in Lake Michigan-Huron by the mid-twenty-first century to +2.451m in Lake Michigan-Huron by the late twenty-first century. The results also highlight the variability among different GCMs and their impact on water level predictions.

S. Bhadbhade, T. Kearns, Great Lakes Observing System, Data Management. **A New Marine IoT Technology Platform - Serving All of the Great Lakes**.

The Great Lakes Observing System (GLOS) supports the collection, management, and sharing of data from buoys, scientific models, and satellite imagery. GLOS is embarking on an ambitious development plan to build a technology platform to support a connected information ecosystem that will serve the Great Lakes region. The traditional approach to problem solving has been limited by single use, disposable data, the high cost of technology, and barriers to data sharing. Fortunately, there has been a shift in the technology landscape making it easier and faster than ever before to access valuable, accurate information in a timely manner. Dramatic advances in smart technologies, communication, processing, and information dissemination further enable "smart," information-driven solutions. GLOS envisions a technology platform that is scalable, secure, open, and dynamic, leveraging existing cloud resources wherever possible. The primary inputs to this ecosystem will be smart sensors and devices. A wide range of workflows and community members will be able to contribute to and consume data and information from the GLOS marine IoT technology platform.

T. Kearns, Great Lakes Observing System, Data Management; K. Paige, Great Lakes Observing System. **Costs and Approaches to Comprehensive High Resolution Mapping of the Great Lakes**.

The Great Lakes cover nearly 250,000 square kilometers yet only a tiny fraction of the Great Lakes bathymetry and corresponding benthic habitats have been mapped with high-resolution technology. Having access to this foundational data about the lakebed will improve decision making about marine navigation, sediment management, coastal erosion, fisheries and ecosystem management, human health, cultural resources, and more. The true cost and potential methods for approaching these challenges are unknown and poorly documented. The Great Lakes Observing System commissioned desktop studies from three experienced hydrographic surveying companies to help better understand and communicate the costs and strategic approaches that could be exercised to fully map the region in high definition. NOAA has also undertaken a comprehensive study to understand the requirements and impacts to resources and budgets for additional mapping in the Great Lakes region. GLOS has compiled these results together to present a clear understanding of the budget required and potential approaches for high-resolution mapping of the Great Lakes.

P. Kebec, Great Lakes Indian Fish and Wildlife Commission, Division of Intergovernmental Affairs; O.H. Schwartz, Great Lakes Indian Fish and Wildlife Commission, Division of Planning and

Development. **Discussion on the Chippewa Ceded Territory Traditional Food System Regulatory Project**.

From 2017-2020, the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) embarked on a project funded by the Administration for Native Americans to provide tools to assist its 11 member tribes in making traditional treaty-harvested foods more accessible and also providing increased opportunities for tribal economic development in the area of food-related enterprises. During the course of this project, staff embarked on food safety and legal research and community outreach to inform the development of regulations for 16 important Ojibwe traditional foods identified by community members. The presentation will provide an overview of the project and offer lessons learned.

K. Keeshig, D. Soney, University of Windsor, Great Lakes Institute of Environmental Research; C. Jacobs, Bkejwanong Territory/Walpole Island First Nation, NinDaWaabJig Heritage Centre; C. Donaldson, University of Windsor, Integrative Biology; C.M. Febria, University of Windsor, Great Lakes Inst. for Env. Research (GLIER) & Dept. of Integrative Biology. **Building a holistic research program to address freshwater restoration through a community-centred approach**.

Indigenous nations have been continuously excluded from decision-making processes that directly affect their Territories and way of life. With calls for reconciliation and Indigenous self-determination in research and resource management, institutions and organizations are looking to develop or improve relationships with Indigenous communities. However, given that mainstream approaches have historically excluded Indigenous communities and Indigenous people continue to be underrepresented in Western sciences, few examples exist on how to ethically and practically go about this. This presentation will explorea community-centred approach to relationship-building and research co-productionby a University research lab and a First Nation community in the Traditional Territory of the Three Fires Confederacy of First Nations. Leveraging a federally funded project to restore aquatic species at risk habitat withinBkejwanong Territory, this presentation will look at how our teams are journeying together to move beyond standard research programs and objectives, and towards Indigenous-led stewardship and community goals.

W. Kerfoot, Michigan Technological University, Great Lakes Research Center, Biological Sciences. **Coastal remote sensing: Comprehensive data integration of stamp sand drift onto Buffalo Reef**.

We utilize geospatial analysis to generate physical, chemical, and biological maps to assess the impacts of historical mining on Buffalo Reef, a vital lake trout and whitefish spawning reef in Lake Superior's Keweenaw Bay. Since 1932, wind and wave generated dispersal of shoreline deposits of mine tailing wastes threaten this benthic environment and vital fish spawning habitat. Aerial photographs, five LiDAR and multispectral over-flights (2008-2016), and ROV/Ponar studies emphasize: 1) the extent of stamp sand mass moving along the shoreline and, 2) the bathymetric complexities of an equal amount migrating underwater. Tailings mix with natural sands, yet distinct end members: 1) allow quantification of stamp sand percentages, 2) aid indirect and direct assays of copper concentrations, and 3) permit determinations of effects on benthic macro-invertebrates. Geospatial mapping demonstrates stamp sand migration onto Buffalo Reef, and their influence the density of benthic communities.

J. Kessler, E.J. Anderson, NOAA, Great Lakes Environmental Research Laboratory; Y. Hong, University of Michigan, Cooperative Institute for Great Lakes Research (CIGLR); L.M. Fry, NOAA, Great Lakes Environmental Research Laboratory; A. RafieeiNasab, B. Khazaei, National Center for Atmospheric Research. **Simulating coastal flooding in Lake Michigan with a land-lake coupled framework**.

Coastal inundation is typically caused by three physical processes: coastal storm surge and wave run-up, pluvial (precipitation-based) flooding, and fluvial (river-based) flooding. Traditionally, these three processes are represented separately by hydrodynamic and hydrologic models. This approach, however, fails to represent complex interactions between these processes such as compound flooding and backwater effects which motivates the need for model coupling. Using a coastal flooding event along Western Lake Michigan as a test case, this work aims to develop a framework in which a hydrodynamic model (FVCOM) is two-way coupled with a hydrologic model (WRF-Hydro). Streamflow and lake water levels are validated as a means to show how model coupling can improve simulation of flood events in forecasting models.

M.M. Kindree, University of Toronto Scarborough, Department of Biological Sciences; N. Jones, Trent University, OMNRF; N.E. Mandrak, University of Toronto Scarborough, Department of Biological Sciences. **Invasive species driven changes in tropic level and diet composition of a native stream fish**.

The ability of invasive species to occupy niche space in novel environments often puts them in competition with native species and may have consequences for food-web structure. The Round Goby is a recent and prolific invader in the Laurentian Great Lakes. We hypothesize that its aggressive nature in occupying benthic space and consuming prey may have consequences for native benthic fishes in terms of competition and niche breadth. Native White Sucker is an important link between offshore benthic energy and nearshore habitats and its recent decline may have a significant impact on energy balances. A hypothesis for this decline is competition with invasive Round Goby. Stable isotopes and gut content analysis were used to elucidate the direct effect of Round Goby on White Sucker prey abundance, diversity, and trophic level. This is the first study to address the hypothesis that White Sucker declines in Ontario are driven, in part, by the invasion of Round Goby.

L. King, Wilfrid Laurier University, Political Science. **Wild Swimming as Citizen Science? Immersion, Local Knowledge, and Water Advocacy for Our Great Lakes**.

We can fight all of the familiar battles against critical environmental challenges, but more than this, people need to imagine the waters of the Great Lakes basin as integral to their daily lives. To this end, wild swimmers are a vital bellwether – a committed athletic community of citizen scientists and clean water advocates. Open water swimmers access the waterfronts, and navigate the shorelines of parks and protected areas year round, continually adapting to changing winds, waves, chop, currents, light, and air and water temperatures. Yet waterfront lands are increasingly closed off to public access and use. Industrial waste and agricultural runoff renders beaches unswimmable. Wild swimmers build resilience during immersion in demanding aquatic conditions, by managing risk, practicing water safety, swimming in teams, evaluating performances and learning from mistakes. Great Lakes open water swimmers teach the public by their example that our lakes are swimmable, drinkable and fishable.

T. Kisekelwa, Institut Superieur PÃƒÂ©dagogique de Bukavu (ISP Bukavu), Biology. **Environmental investigation of fish in Lake Kivu, a lake with a complex history**.

Eastern Africa is endowed with enigmatic lakes. Lakes Tanganyika, Victoria, and Malawi are highly diversified whereas Lake Kivu is not, with relatively fewer species. The low species diversity in Lake Kivu is explained by its recent formation and past, dramatic subaquatic volcanic events that destroyed fish fauna. Inadvertently, the extent to which habitat heterogeneity may explain the fish fauna of Lake Kivu has never been investigated. In this study, sampling was standardized using a multi-mesh gillnet at over 14 localities from the north to the southern part of the lake for 12 months between April 2018 and October 2019. Twelve environmental variables were sampled alongside fish

samples. Eighteen fish species were identified over the lake corresponding to the diversity in the North and 15 of that from the South. The species abundance indicated human effects on fish fauna. We conclude that habitat heterogeneity could trigger species diversification in Lake Kivu. Through ACARE, we hope to integrate trophic level and genetic research across the lake spatial scale.

C. Kitchens, University of Michigan; M.D. Rowe, NOAA GLERL; C.M. Godwin, University of Michigan, Cooperative Institute for Great Lakes Research. **Distribution and Speciation of Manganese With Respect to Hypoxia in the Central Basin of Lake Erie**.

Seasonal hypoxia in Lake Erie's central basin can cause the release of the heavy metal manganese (Mn) from sediment, which can reach concentrations over 1 mg L-1 in the water at certain locations. Mn can cause discoloration in drinking water and is increasingly regulated owing to concerns over human health. However, we lack a comprehensive dataset on the distribution and forms of Mn with respect to hypoxia in the lake. As part of CSMI 2019 we performed a comprehensive sampling program to measure the distribution and forms of Mn before, during, and after establishment of hypoxia in the central basin. Elevated dissolved and total Mn occurred earliest in nearshore hypoxic zones where hypolimnion is thin, and later spread to deeper areas of the basin. These results are consistent with our recent laboratory experiments showing that Mn flux begins under hypoxia and could help predict when and where Mn accumulates to concentrations that have potential to impact drinking water treatment.

M. Kitson, University of Minnesota Duluth, Minnesota Sea Grant; K. Shchapov, University of Minnesota Duluth, Large Lakes Observatory. **How to Connect to Educators and Tomorrow's Decision-makers**.

The Great Lakes Sea Grant Network fosters scientist-educator and scientist-youth interactions to increase youth engagement in Great Lakes science education. Scientist-educator interactions increase educators' knowledge and confidence in the ability to teach Great Lakes science. During these interactions, a scientist hones his/her/their ability to communicate with non-scientists and highlights the research that he/she/they is/are doing. Scientist-youth interactions provide a chance to instill passion about his/her/their chosen profession and serve as a model to aspiring youth. Join this presentation to learn tips and tricks for communicating with educators and youth and about upcoming opportunities for connecting with educators.

M. Klasic, University of California, Davis, Center for Environmental Policy and Behavior; R. Lamb, University of Maryland, College Park, Geographical Sciences; K. Leonard, University of Waterloo, Faculty of Environment; V. Vargas-Nguyen, University of Maryland Center for Environmental Science, Integration and Application Network. **What's HAB-ening to Lake Erie? Using social-ecological network analysis to target action**.

Research in environmental governance shows that misalignment between management boundaries and ecological systems can be addressed through collaboration. Social-ecological network analysis (SENA) considers actors (social and ecological) and multiple types of relationships. Using planning documents from 2012–17, we apply SENA to explore Lake Erie HABs management, a system that continues to face fractured governance despite over 40 years of effort. Our multidimensional approach builds on existing SENA research by considering the multiple nuanced relationships between and among actors in the Lake Erie system. Results provide insights into governance actors (1000+ organizations), social relationships (Indigenous Nations are often excluded from substantive collaboration), and social-ecological relationships (strong collaboration occurs in a subset of watersheds). This research helps decision-makers identify and target weak links among actors and across watersheds to strengthen management.

N. Kokilathasan, M.B. Dittrich, University of Toronto Scarborough, Department of Physical and Environmental Sciences. **Nanoplastics: Impacts and Detection in Aquatic Environments - A Review**.

The rise in global production of plastics since its creation in 1839 has raise concerns on its impacts in aquatic environments, especially regarding nano-sized plastics (or nanoplastics). Nanoplastics differ from macro- and micro-sized plastics in many ways, due to their small size and very large surface area. This allows them to bypass cell membranes and bioaccumulate in the tissues and organs of organisms. Still, very little is known about nanoplastics compared to microplastics. This review describes the potential sources of nanoplastics, the ecology of the plastisphere, interactions between nanoplastics and aquatic biota, and current methods of detection. We also identify gaps in knowledge and future directions in addressing the detection and analysis of nanoplastics.

M.S. Kornis, U.S. Fish and Wildlife Service, Green Bay Fish and Wildlife Conservation Office; J. Webster, A. Lane, K. Pankow, S. Cressman, T. Treska, C.R. Bronte, US Fish and Wildlife Service. **Movements of coded-wire tagged Chinook salmon, lake trout, and steelhead in lakes Michigan and Huron**.

Millions of salmonines are annually stocked in the Great Lakes to support and diversify sport fisheries and restore native fish populations. The U.S. Fish and Wildlife Service began coded-wire tagging and adipose-fin clipping all lake trout stocked into Lakes Michigan and Huron in 2010; tagging of Chinook salmon and steelhead followed in 2011 and 2017, respectively. One study objective is to better understand movement patterns and provide spatial considerations for management. Chinook salmon movement is unconstrained in lakes Michigan and Huron, with fish recovered up to 530 km away from their stocking location (average. = 140 km), although mature Chinook salmon home to their stocking locations or natal streams to spawn. This has supported management of this species as a single stock in each lake. By contrast, most lake trout are recovered 100 km from the stocking location, with dispersal varying among ecomorphtypes, informing the development of discrete stock assessment units. Preliminary data suggest steelhead movements are more similar to those of Chinook salmon than lake trout. Management applications will be discussed.

E. Kostelnik, Valparaiso University, Department of Chemistry; J. Peller, Valparaiso University, Chemistry; M. Byappanahalli, M. Nevers, U.S. Geological Survey - Great Lakes Science Center, Lake Michigan Ecological Research Station; C. Nelson, RUTGERS UNIVERSITY; B.G. Babu, Valparaiso University, Geography; M. Evans, USGS, Great Lakes Science Center; M. Keller, Valparaiso University, Chemistry; J. Johnston, Valparaiso University, Geography; S. Shidler, Renishaw Inc. **Synthetic microfiber loads in green algae, Cladophora, in Lake Erie and Lake Michigan**.

Synthetic microfibers, a category of microplastics, have been found throughout surface waters worldwide. The microfiber polymers are mostly denser than water and become submerged in water environments. Thus, surface water samples likely do not accurately account for microfibers loads, which integrate into other areas of the aquatic environment. One ecological sink for synthetic microfibers may be submerged aquatic vegetation (e.g. Cladophora, a nuisance green alga). Throughout the Laurentian Great Lakes, Cladophora creates large areas of submerged biomass, which can potentially concentrate these microfibers. To quantify the loads of synthetic microfibers in Cladophora, algal samples were collected in 2018 from Lake Erie and Lake Michigan at different depths and months. The samples were cleaned and processed to eliminate natural fibers. The average load of synthetic microfibers in Lake Erie samples was 32,000 microfibers/kg (dw) and

34,000 microfibers/kg (dw) in Lake Michigan. These findings suggest that submerged vegetation such as Cladophora is an additional sink for synthetic microfibers introduced through waterways.

I. Kraucunas, V. Bailey, Pacific Northwest National Lab; R. Hetland, Pacific Northwest National Laboratory; T. Bridgeman, University of Toledo, Lake Erie Center & Dept. of Environmental Sci.; P. Xue, Michigan Technological University, Civil & Environmental Engineering. **New U.S. DOE project on coastal observations, mechanisms, and predictions across systems and scales**.

The U.S. Department of Energy has launched a new project entitled Coastal Observations, Mechanisms, and Predictions Across Systems and Scales (COMPASS). This multi-institutional effort has a decadal goal of enhancing predictive understanding of both freshwater and saltwater coastal systems, with an emphasis on (1) what multiscale mechanisms govern the structure, function, and dynamics of coastal systems? (2) how coastal systems respond to natural and anthropogenic influences, and (3) generalizing new process knowledge and predictive skill across a diversity of coastal systems? One of our pilot studies focuses on modeling how the Great Lakes region is responding to climate warming and land use and land cover changes from watershed to regional scales; the other on measurements, experiments, and process modeling of the interactions among waters, soils, and plants that drive fluxes and transformations of carbon, nutrients, and redox elements across the terrestrial–aquatic interface.

R.M. Kreiling, United States Geological Survey; L. Bartsch, P. Perner, K. Breckner, T. Williamson, US Geological Survey. **PHOSPHORUS RETENTION POTENTIAL IN THE RIVERBED SEDIMENTS OF THE MAUMEE RIVER BASIN**.

Studies have shown that the Maumee River delivers a significant portion of annual phosphorus (P) load to Lake Erie that drives harmful algal blooms each summer. Sediment can be a source or sink for P via biotic uptake and abiotic processes; however, limited research has occurred in riverbed sediments in the Maumee River basin to assess if sediment characteristics influence P delivery to Lake Erie. In summer 2019, we sampled riverbed sediment at 78 sites throughout the river network to measure sediment P concentrations and indices of sediment P retention potential. We calculated total P stored in fine sediments in two small watersheds. We observed that sediment total P increased with organic content. Sediment P retention potential was related to bioavailable P concentration in sediment and particle size with finer sediments potentially retaining more P. Sites in the southern half of the basin were likely P sinks, whereas sites in the northern half were likely sources of P to the water column. Thus, riverbed sediments may be moderating or contributing to the storage and remobilization of P in the stream system and, ultimately, the P load entering Lake Erie during summer.

A. Kuczynski, National Institute of Water and Atmospheric Research, Freshwater Modelling; M.T. Auer, Michigan Technological University, Civil & Environmental Engineering; A. Grimm, C.N. Brooks, Michigan Technological University, Michigan Tech Research Institute. **Predicting algal debris risk at water intakes: an application of the Great Lakes Cladophora Model v3**.

Phosphorus-driven nuisance growth of the filamentous green alga *Cladophora* has wreaked havoc in the lower four Great Lakes for decades. The Great Lakes *Cladophora* Model version 3 (GLCM v3) simulates algal biomass density and stored (cellular) phosphorus content. The model has been calibrated and tested against data sets for Lakes Huron, Michigan, Erie, and Ontario. The tool was developed primarily to support ecosystem managers and has been used in conjunction with lake bottom and beach monitoring data to support development of an early warning system to alert a nuclear power plant of the risk of algal debris entering a cooling water intake in northern Lake Ontario. While alerts of algal debris events are extremely useful for managing power plant operations and averting devastating economic losses due to algae-related shut-downs, the model can

also be used to set target ambient phosphorus objectives to limit algal growth in critical nearshore areas (e.g., close to power plants).

J.T. Kvistad, Central Michigan University; L. Chadderton, A. Tucker, The Nature Conservancy; T. Galarowicz, Central Michigan Univ.; D. Castle, Little River Band of Ottawa Indians; D. Clapp, J. Milan, K. Snyder,, Michigan DNR, Fisheries Division; M. Herbert, The Nature Conservancy; P. O'Neill, Michigan DNR, Fisheries Division. **WITHDRAWN: Ecology and life history of the invasive rusty crayfish on northern Lake Michigan spawning reefs**.

Non-native rusty crayfish are abundant egg predators on spawning reef habitats for lake trout and coregonines in northern Lake Michigan. Yet aspects of the ecology and life history of rusty crayfish across the waters of the Great Lakes are understudied. Here we summarize data from over a decade of research into rusty crayfish management on native fish spawning reefs in northern Lake Michigan and report our findings on substrate preferences, seasonal variation in abundance, spawning phenology, and fecundity. Observed patterns are mostly consistent (or comparable) with previously published data from inland populations, but we note some important differences and discuss these in the context of non-native crayfish management. Finally, we underscore the importance of basic ecological research for developing successful non-native species management strategies.

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R. Guiasu, M. Labib, Glendon College, York University, Biology Program. **What is the native range of the invasive" rusty crayfish (Faxonius rusticus)?"**

The concept of native range in invasion biology is difficult to define. In many cases, this type of range is unknown and cannot be determined. We investigated the uncertainties related to this concept by focusing on the distribution of the rusty crayfish (*Faxonius rusticus*), which is perceived as possibly the worst invasive crayfish species in North America. We completed an extensive literature review, which included 430 studies published between 1852 and 2018, in order to analyze the native and non-native ranges of this species. The rusty crayfish was reported to occur in 33 states in the U.S.A. and 3 Canadian Provinces. Ten of these U.S. states and one Canadian Province have been included multiple times in both the native and the non-native ranges of this crayfish. The confusion regarding the limits and history of the native range of the rusty crayfish has implications for the conservation of this species in various jurisdictions. This review also shows that even for intensely studied species perceived as invasive, we often do not have a clear understanding of essential concepts such as native and non-native range.

A. Lad, J. Breidenbach, D.J. Kennedy, S. Haller, The University of Toledo College of Medicine and Life Sciences. **Pre-existing liver disease increases susceptibility to chronic low-dose Microcystin-LR exposure**.

Microcystin-LR (MC-LR) is a common toxin produced in cyanobacterial blooms. While MC-LR is a known liver toxin, there is little data on the effects in settings of common pre-existing liver diseases such as Non-alcoholic Fatty Liver Disease (NAFLD). We hypothesized that NAFLD increases the susceptibility to chronic low-dose MC-LR exposure and that targeted treatment with antioxidants may potentially act as a therapeutic in reducing this liver injury. We exposed both healthy and NAFLD mice to chronic, low-doses of MC-LR. While these levels of MC-LR exposure had no observable effect in healthy mice, NAFLD mice demonstrated a significant increase in liver injury. Augmenting the specific MC-LR detoxification pathways with antioxidant therapy, we were able to improve liver metabolism of MC-LR and reduce MC-LR induced liver injury in NAFLD

mice. This suggests common liver diseases such as NAFLD increase susceptibility to MC-LR and targeted antioxidant therapy may provide therapeutic benefits.

P. Landisch, University of Minnestoa, Forest Resources; L.H. Elliott, University of Minnesota, Forest Resources; W. Severud, University of Minnesota; M. Nelson, US Forest Service; J. Vogeler, Colorado State University; J. Knight, University of Minnesota, Remote Sensing and Geospatial Analysis Laboratory. **A decision support tool for prioritizing coldwater stream habitat restoration and management**.

Efforts to manage coldwater stream habitat are complicated by the impacts of landscape characteristics on watershed condition. Decisions for siting restorations must account for both in-stream characteristics and spatiotemporal patterns of land use, land cover, and disturbance in the surrounding landscape. We used a watershed framework to assess terrestrial characteristics across US Great Lakes watersheds at multiple spatial scales, both inside and outside riparian areas. Examining interactions between terrestrial characteristics and brook trout occupancy through a multiscale approach improves the predictive power of a decision support tool. We incorporated these metrics into brook trout (*Salvelinus fontinalis*) occupancy models in Minnesota. We are developing an interactive ArcGIS StoryMap to display results and prioritize subwatersheds for restoration and barrier removal. Our StoryMap is the first step in developing a prioritization tool to support and guide restoration activities.

S.M. Larocque, University of Windsor, GLIER; T. Johnson, Ontario Ministry of Natural Resources; J.D. Midwood, Department of Fisheries and Oceans, Fisheries and Oceans Canada; D. Gorsky, U.S. Fish and Wildlife Service; M. Connerton, NYS DEC; A.T. Fisk, University of Windsor, GLIER. **Combining spatial movements and diet to better understand salmonid ecology in Lake Ontario**.

In Lake Ontario, six salmonids are part of an economically important recreational fishery, with two native species undergoing restoration efforts. Understanding spatial habitat use and diet among species can identify potential competitive bottlenecks impacting native species restoration and overall fishery sustainability. We used acoustic telemetry data from 2016-2019 (n = 148) and stable isotopes collected in 2018 (n = 425) to assess the spatial and dietary overlap of the salmonid community in Lake Ontario. Most salmonids were highly mobile and occupied large areas of Lake Ontario, while lake trout (*Salvelinus namaycush*) and brown trout (*Salmo trutta*) showed more residency. Atlantic salmon (*Salmo salar*), Chinook salmon (*Oncorhynchus tshawytscha*) and coho salmon (*Oncorhynchus kisutch*) had high dietary overlap, while rainbow trout (*Oncorhynchus mykiss*), brown trout, and lake trout had more distinct diets but all six species had a high reliance on alewife (*Alosa pseudoharengus*). The combined analyses allowed us to further our understanding of salmonid ecology in Lake Ontario and will assist in sustainable fisheries management.

C.E. Larson, University of Minnesota, Duluth, Department of Biology; J. Barge, Oak Ridge Associated Universities; C. Hatzenbuhler, SpecPro Proffesional Services; A. Trebitz, U.S. EPA, Office of Research and Development; J.C. Hoffman, US EPA, Great Lakes Toxicology and Ecology Division; E. Pilgrim, US EPA; G. Peterson, US EPA Office of Research and Development; S. Okum, ORISE, US EPA; B. Wiechman, US EPA. **Dreissena transport from St Louis River to Apostle Islands detected in eDNA and zooplankton surveys**.

Lake Superior is generally inhospitable to the establishment of invasive Dreissena; yet colonies are reported in the Saint Louis River estuary (SLRE) and Apostle Islands National Lakeshore (APIS). A 2017 survey determined low abundance Dreissena spatial distribution in APIS, which suggested veliger transport from SLRE (most established population in Lake Superior) via summer currents. Our objective in this study was to determine if Dreissena veligers are transported from

SLRE to APIS by sampling the presumed longshore transport. To do so, we used both eDNA (water and mesh banner samples) and zooplankton collection methods. Dreissena veligers were consistently detected along the south shore at low abundances, and for every 1 km increase in distance from the SLRE, individuals and eDNA copies/uL decreased on average by 5% and 7%, respectively. D. polymorpha (suited to estuary habitat) was detected 2 times more than D. bugensis. Findings represent multiple sources of evidence of a propagule "conveyor belt" for Dreissena along the south shore of Lake Superior, with implications for further invasion across habitat previously reported as inhospitable.

G. Lau, University of Minnesota Duluth; C. Hill, University of Minnesota Duluth, Mechanical and Industrial Engineering.**WITHDRAWN: Great Lakes wave energy resource classification and Blue Economy opportunities**.

The Great Lakes (GL) environment is the World's largest freshwater resource, and with growing interest in GL offshore wind energy, availability of other marine energy resources needs to be assessed. Wave energy conversion has proven to viably contribute towards energy demands at small scales, particularly for Blue Economy industries. The GL has largely been overlooked in other assessments focusing on coastal waters, yet its marine resource presents opportunities and unique challenges for wave energy R&D, Blue Economy applications and to augment national energy resource and planning databases. Discussion will focus on updates from an ongoing study calculating the spatial and temporal distributions of wave resource parameters following IEC standards and the US Department of Energy's wave energy resource classification system. Results focus on estimating annual energy potential and the role the GL could play towards sustainably developing unique solutions for the Blue Economy.

H. Buffum, General Dynamics Information Technology; B. Blackwell, U.S. Environmental Protection Agency; J. Frisch, H. Helgen, W. Melendez, General Dynamics Information Technology; J. Launspach, GDIT contractor to USEPA. **Utilizing Qlik to visualize the multiagency spatiotemporal data driving effects-based monitoring**.

The Great Lakes Restoration Initiative (GLRI) began in 2010 aimed at protecting and restoring the country's largest freshwater resource. One component of the GLRI involves consideration of the adverse impacts of complex mixtures of legacy chemicals and contaminants of emerging concern (CECs) on Great Lakes fish and wildlife. To address this issue, a multi-agency research consortium with technical expertise in the monitoring/surveillance of environmental contaminants and biological effects in ecologically-relevant species was assembled. The partners include U.S. Environmental Protection Agency, U.S. Geological Survey, National Ocean and Atmospheric Administration, U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, Clarkson University and St. Cloud State University. The approach chosen by the team to address the multifaceted challenge of complex mixture assessment involves linking extensive analytical chemistry measurements to effects-based monitoring (EBM) data collected using different types of biological systems. Through these studies, the consortium has and continues to generate a large amount of diverse chemical and biological data. This data is consolidated and formatted using an extensive quality assurance and quality-controlled process. Qlik was originally used as a Business Intelligence tool and has been repurposed throughout the QA/QC process to identify outliers. Once the data has been vetted and placed in the project's MySQL database, it is exported to create Qlik front-end applications. The Qlik software allows for visualizing large datasets at one time in a variety of different formats. These formats can be custom built to meet the clients' needs and allow for filtering and exporting to an image or table for further analysis. The goal, once approved, will be to make this and other Qlik applications available publicly for other researchers to use in the Great Lakes region.

R. Lauzon, Chippewas of Nawash Unceded First Nation; K. Almack, Ontario Ministry of Natural Resources and Forestry; E.S. Dunlop, ON Ministry of Natural Resources, Trent University; A. Duncan, Chippewas of Nawash Fishery Assessment. **Together with Giigoonyag: Developing an Acoustic Telemetry Array for Ontario waters of Lake Huron**.

The movement of lake whitefish between management areas and basins of the Ontario waters of Lake Huron is not well understood. The Ontario Ministry of Natural Resources and Forestry, Parks Canada, and Saugeen Ojibway Nation (SON) have recently begun a five year project to develop an acoustic telemetry array to track lake whitefish movement within Lake Huron. In this presentation we discuss how we are applying the "Two-Eyed-Seeing Approach" by using both western science and SON's ecological knowledge to inform project design. Our project will fill key knowledge gaps in the movement of lake whitefish and inform future monitoring programs and management decisions.

P.L. Lawrence, E. Teye, University of Toledo, Department of Geography and Planning. **Spatial Distribution Model for Manure from Permitted Livestock Facilities, Maumee Watershed, Ohio**.

This study aimed at developing an economic utility for producers in transporting manure to reduce potential environmental impacts that may arise from over application. The initial basic feasible solution of the Hitchcock transportation model was used to simulate distribution of manure from 31 dairy and swine concentrated animal feeding facilities to agricultural census block groups (soybeans and corn) in the Maumee Watershed, Ohio. The model considered the supply and demand capacity of nearby livestock operations (origin) and agricultural census block groups (destinations) respectively. The distribution of manure showed an unbalanced transportation problem such that available farmland that could receive manure exceeded the supply of the livestock operations. Additionally, areas indicating clustering in distribution of manure were examined to determine potential for nutrient transport off the land and into nearby waterbodies based on the environmental conditions used.

C. Lee, K. Wolley, AquaRealTime. **Early detection of HABs using low cost, networked sensor buoys.**

Despite ongoing innovations in monitoring HABs, existing technologies lack sufficient resolution to adequately inform HAB research and mitigation efforts, or are too expensive to deploy at the scale necessary. Manual sampling efforts are also limited at scale. The authors have developed a technology wherein networked, lightweight, low cost sensor buoys can be rapidly deployed to multiple locations in a lake and report real time data autonomously. Each buoy measures and streams levels of chlorophyll, phycocyanin, turbidity, air and water temperature, light, and GPS, and creates automated alerts when levels exceed a set threshold. We will present: A review of fluorescence based HAB sensing A description of the technology A review of results from field studies in Colorado, California, Indiana, Massachusetts, Wisconsin. A discussion of upcoming work on algorithms to improve accuracy.

P.L. Lenaker, S.R. Corsi, U.S. Geological Survey; S. Mason, Penn State Behrend. **From Rivers to Lakes - The Movement and Distribution of Microplastics from Tributaries to the Great Lakes**.

The distribution of microplastic particle types (fibers, fragments, beads/pellets, films, foams) have been found to vary in the water surface with a low proportion of fibers (14%) in the offshore Great Lakes and high proportion (> 70%) in the tributaries. Despite knowledge of microplastic presence, little is understood about the distribution and fate of microplastics in the Great Lakes. Two follow-up studies were conducted to understand the distribution and fate of microplastics in

the Great Lakes and tributaries: (1) evaluate the vertical distribution of microplastics in the water column; (2) quantify microplastics in sediment samples from Lake Michigan and Lake Erie. Microplastics of all types were observed in every sediment and water sample collected. Microplastic particles were distributed throughout the water column and sediment with increasing particle density from the water surface through the water column to the sediment. Results indicate that the discrepancy between high proportions of fibers in the water surface of the tributaries compared to the Great Lakes is explained by fibers settling through the water column and into the sediments.

C. Lenard, J.D. Lenters, G.A. Meadows, Michigan Technological University, Great Lakes Research Center. **Characterizing the 2020 wave climate of Lake Superior with a new network of Spotter buoys**.

Historically, recreation on the Great Lakes has come with an elevated level of risk due to a lack of extensive wave data, with over 900 drownings reported on the Great Lakes since 2010. In 2020, a small network of new "Spotter" wave buoys was deployed on Lake Superior to address data gaps and public safety needs that were exacerbated by COVID-related delays in regular buoy deployments. Two Spotter buoys were placed in nearshore locations that are popular for fishing and boating, while a third buoy was anchored offshore near Stannard Rock lighthouse. The buoys collect data on wave height, period, and direction, as well as other parameters related to hazardous lake conditions. We found that occasional spikes in the wave height and wave period data require a simple QA/QC routine to identify outliers, after which the data are then suitable for analysis. This presentation provides an overview of the project and preliminary results from our wave characterization study.

P. Lennox, Ontario Ministry of Natural Resources and Forestry, Science and Research Branch. **The Development of Community-Based Environmental Monitoring Program with Weenusk First Nation**.

In 2018, at a Mushkegowuk land use planning workshop, a collaborative among Weenusk First Nation, OMNRF, and WCS Canada was formed to build relationships and environmental monitoring capacity with Weenusk First Nation. Here we discuss our experience in the development of a community-based monitoring framework in the remote community of Peawanuck, and relate aspects of collaboration, relationship building, and knowledge sharing with the community.We describe aspects of our journey such as knowledge sharing workshops, relationship building efforts, and collection of environmental data (fisheries, water quality, invertebrate, soil and peat core samples) alongside youth, Elders and community members. Furthermore, we identify barriers which had to be overcome, including funding and organizational constraints, and cite the importance of educating western scientists on the value of local and Indigenous knowledge perspectives. We hope by sharing this experience to highlight the importance of passionate people and partnerships, early relationship building in the research process, and bridging knowledge systems through mutual learning on the land.

J.D. Lenters, C. Lenard, Michigan Technological University, Great Lakes Research Center; P. Xue, Michigan Technological University, Civil & Environmental Engineering; G.A. Meadows, Michigan Technological University, Great Lakes Research Center; C. Huang, Michigan Technological University, Civil & Environmental Engineering. **Waves and circulation on Lake Superior during an intense autumn gale: The Halloween storm of 2020**.

Characterization of surface waves and currents on the Great Lakes is fraught with challenges, not the least of which is the sparse network of data buoys. Although the observational coverage on Lake Superior has improved over the years, information on currents and circulation is especially lacking. Following the deployment of a new "Spotter" wave buoy near Stannard Rock in July of

2020, the buoy drifted free during a strong southerly gale on October 31, after which winds switched to the northwest and increased above 50 knots. With wave heights building to 20 feet, this large storm event provided a unique opportunity for observing currents in central Lake Superior during an intense autumn gale. We provide an overview of the meteorological and lake data collected during this experiment, including the track of the buoy over a roughly 4.5-day period. Results are compared with numerical model simulations to evaluate the accuracy of drift velocity forecasts during large wave events.

R. Lepak, University of Wisconsin-Madison, Aquatic Sciences Center; J.C. Hoffman, US EPA, Great Lakes Toxicology and Ecology Division; S. Janssen, USGS Mercury Research Lab; M. Gordan, US EPA Office of Research and Development, ORD/CCTE/GLTED; M. Tate, USGS Mercury Research Lab; A. Cotter, US EPA Office of Research and Development, ORD/CCTE/GLTED; J. Ogorek, D. Krabbenhoft, USGS Mercury Research Lab; E.W. Murphy, U.S. EPA, Water Enforcement & Compliance Assurance Branch; J. Hurley, University of Wisconsin - Madison, Wisconsin Sea Grant. **Reconstructing the energy pathways and contaminant burden to lake trout in contrasting Great Lakes**.

Evaluating the reduction of contaminants in the Great Lakes has relied on sediment core reconstructions and long-term biological monitoring and specimen archiving. For some chemicals, these retrospective approaches can reveal differing narratives about the success of reducing contaminant loading to the Great Lakes. Interpreting contaminant trends in fish through time is challenging because they are mobile, express individuality in resource use and are highly sensitive to physical, ecological, and biological changes. Yet, contaminant reductions in fish are a prized marker of success in resource management. Here, we present bulk and compound-specific stable carbon and nitrogen isotope ratios in two lake trout archives from Lakes Superior and Michigan to evaluate the impact biological and ecological changes have on energetic pathways and the mercury burden in lake trout. Then we ask are fish responding to declining emissions and how do fish influence the variability in contaminant burden?

G. Leshkevich, Great Lakes Env. Research Lab, NOAA; R. Shuchman, M.J. Sayers, K. Bosse, Michigan Technological University, Michigan Tech Research Institute. **An in situ IOP/AOP database for Great Lakes satellite bio-optical algorithm development and product validation**.

High quality in situ measurements of inherent and apparent optical properties (IOP/AOP) along with concurrent measurements of color producing agent (CPA) concentrations are necessary for the development of satellite algorithms for retrieval of water quality properties and for data product validation. Starting in 1997, a twenty year database of in situ water optical properties with concurrent CPA concentrations has been measured at various mid-lake and near shore sites on each of the Great Lakes at various times throughout the ice-free season. Archived data include measurements of inherent and apparent optical properties, chlorophyll-a, color dissolved organic matter (CDOM), dissolved organic carbon (DOC), suspended minerals (SM), and other related data. Data were collected using a number of different instrument packages including profiling and floating radiometers and hand-held instruments. To make the data more accessible and usable, current work includes re-formatting the data into the NOAA NESDIS In Situ Ocean Color Optics (ISOCO) Database format (NASA SeaBASS-like format) to be made available via NESDIS, Great Lakes CoastWatch, and MTRI sites.

J.T. Ives, University of Windsor, Great Lakes Institute for Environmental Research; P. Limbu, C. Apse, The Nature Conservancy; I. Kimirei, Tanzania Fisheries Research Institute (TAFIRI); J. Gowele, The Nature Conservancy. **Lessons from fisheries co-management on Lake Tanganyika - Tanzania**.

Lake Tanganyika harbors more than 300 nearshore fish species (cichlids) and two pelagic species of clupeids and their predators contributing up to 200,000 tons of fish annually. The lake supplies 60% of animal protein eaten by fisher community while employing 155,000 of 12 million residents. However, fish catch and productivity in the lake are declining fast due to high fishing pressure, unsustainable fishing practices and climate change – calling for conservation attention. The Nature Conservancy's Tuungane project in west Tanzania collaborates with the Government of Tanzania on fisheries co-management to establish strong local institutions (BMU) at 23 villages which patrol a stretch of 192 km. these 23 BMUs have been confederated into 7 networks (CFMAs) at 7 wards to protect 15 community reserves (FBS). BMUs are collecting Fisheries Cath Assessment Survey (CAS) data monthly for the Government. Community report that fish catch has increase by 33% from 2011 survey.

Y. Lin, University of Michigan; A. Fujisaki-Manome, CIGLR, University of Michigan; E.J. Anderson, NOAA, Great Lakes Environmental Research Laboratory. **Wind stress effects on the mixed layer depth and ice formation in Lake Superior**.

Fall-time mixed layer development is a critical factor to determine how fast the water surface cools down and when lake ice starts to form in the Great Lakes. The current applications of the finite-volume community ocean model (FVCOM) to Lake Superior tend to overestimate ice cover in the lake. One possible reason for the overproduced ice cover is the insufficient vertical mixing of the water surface by the wind stress during early winter. In this study, we evaluate different algorithms for calculating wind stress using the Coupled Ocean-Atmosphere Response Experiment (COARE) bulk flux algorithm in FVCOM to investigate how different wind stress parameterizations change the mixed layer depths and how they affect the processes of ice formation and melting in Lake Superior. The preliminary results for the winter of 2015 show that the mixed layer was deepened and the overestimated ice cover of Lake Superior improved when total wind stress input to the lake increased.

S. Liu, University of Michigan, CIGLR; A.J. VanderWoude, S. Ruberg, NOAA GLERL. **NOAA Great Lakes CoastWatch Coastal Remote Sensing Data and Integration Efforts**.

Great Lakes coastal remote sensing data is disseminated in near real-time for stakeholders through the Great Lakes CoastWatch (CW) node at NOAA's Great Lakes Environmental Research Laboratory (NOAA GLERL). CW is a NOAA/NESDIS program that aims to provide users with a wide range of data services for decision makers, local stakeholders and academic researchers. Stakeholders use products such as the color-producing agents (i.e. chlorophyll and suspended sediment), lake surface temperature, ice coverage, ice classification, and wind speed for coastal services and decision making. Satellite data provides the high spatial and temporal coverage needed to discriminate coastal features whereas in-situ observations conducted at NOAA GLERL that are historically used to validate these products. Examples of coastal CW products will be introduced as well as recent preliminary efforts to integrate NOAA GLERL buoy data and airborne hyperspectral imagery. New products will also be highlighted: GOES-16 visible, VIIRS true-color, and Great Lakes altimeter satellite data.

Q. Liu, University of North Carolina Wilmington, Physics and Physical Oceanography; M.D. Rowe, NOAA GLERL; E.J. Anderson, C. Stow, NOAA Great Lakes Environmental Research Laboratory; R. Stumpf, NOAA; T.H. Johengen, University of Michigan, Cooperative Institute for Great Lakes Research (CIGLR). **Probabilistic forecast of microcystin using remote sensing, in situ observations and numerical model**.

We developed an approach to predict the spatially- and temporally-resolved probability of exceeding a public health advisory level (PHA, 6 ?g/L) of microcystins in the western basin of Lake

Erie through a combination of 1) a 5-day forecast model, 2) a linear regression model to correlate chlorophyll-a and microcystin concentrations from weekly field samples, and 3) observed probability of microcystin concentration exceeding the PHA, conditional on model-predicted microcystins, over a multi-year hindcast period. Assessment for 2017 using metrics for probabilistic forecasts showed the approach provides useful information. To improve the model we included additional years in the training data set, updated the regression model to correlate chlorophyll-a and microcystin concentrations with a Bayesian model, and smoothed the transition between the time periods covered by MODIS and Sentinal-3 satellites with an empirical bias adjustment. The forecast system can be used by drinking water system managers, public health officials, federal, state, and local governments for the management of lake water.

B.M. Llew-Williams, Brock University, Department of Earth Sciences; F.M. McCarthy, Brock University, Earth Sciences; J.P. Pentesco, Brock University, Earth Science. **Hydrological effects of Early Holocene drought on the Upper Great Lakes**.

The Laurentian Great Lakes formed ~15,000 cal BP as the retreating Laurentide Ice Sheet pooled meltwater in glacially scoured basins along dynamically changing ice lobes. The system drains a ~770,000 km2 watershed and flows from L. Superior to the Atlantic Ocean, fed primarily through the connecting rivers (St. Mary's, St. Clair, Niagara, etc.), and influenced by smaller tributaries, over-lake precipitation, and evaporation. The Lake Superior watershed thus controls the quantity and quality of water throughout the Great Lakes. Early Holocene drainage was affected by capture of Lake Agassiz meltwater, isostatically rebounding outlets, and climate. Pollen-derived paleoclimate estimates confirm that the drought that peaked ~8.2 cal BP was sufficient to cause hydrologic closure of Lake Superior. This allowed rapid drawdown and increased salinity in Lakes Chippewa, Stanley, and Hough recorded by microfossil assemblages and in Ojibwa oral histories- an abrupt change in water balance and chemistry in a basin that holds ~18% of the world's fresh water supply.

B.M. Lofgren, NOAA/GLERL, Great Lakes Environmental Research Lab; J. Wang, NOAA Great Lakes Environmental Research Laboratory. **Ice Cover's Influence on Lake Evaporation Over Annual and Multi-Annual Periods**.

Ice cover can drastically inhibit evaporation from lakes over short time periods. That is, a short period without ice cover will have considerably greater evaporation than a subsequent short period with ice cover, if all other conditions are the same. This is primarily due to ice's insulating characteristic of having much reduced conduction of heat relative to liquid water's combination of conduction and eddy diffusivity. However, at the timescale of a year, lake heat lost to evaporation due to later ice onset can result in an offsetting reduction of evaporation after the ice melts. What will be the net effect? A toy model of evaporation at a single water-covered point shows that the net effect on evaporation of decreased ice cover at the annual time scales is much less than the contrast between short ice-free and ice-covered periods. In fact, we are investigating the possibility that reduced ice cover actually reduces overall evaporation. There are also effects on the sensible heat flux, along with effects of surface albedo change associated with ice cover.

T. Long, N. Benoit, Ontario Ministry of the Environment Conservation and Parks, Environmental Monitoring and Reporting Branch; E.T. Howell, ONT Ministry of the Environment, Conservation and Parks, Environmental Monitoring and Reporting Branch; S. Bhavsar, L. Richman, Ontario Ministry of the Environment Conservation and Parks, Environmental Monitoring and Reporting Branch. **Spatiotemporal trends of polychlorinated biphenyls (PCBs) and mercury in Lake Ontario's nearshore sediment**.

The Ontario Ministry of the Environment, Conservation and Parks (MECP) has been conducting multi-media sampling at a network of nearshore stations on the Canadian side of the

Great Lakes since the early 1990s. Surface and suspended sediment samples collected 1994-2018 through the Great Lakes Index and Reference Station Monitoring Program from stations in Lake Ontario and the St. Lawrence River were analyzed for trends in PCBs and mercury, as these two contaminants are the primary and secondary causes of MECP's restrictive fish consumption advisories in Lake Ontario, respectively. Ancillary parameters analyzed in water and/or sediment (e.g. total organic carbon) were also examined to help garner further insight into potential abiotic-biotic contaminant connections in the nearshore of Lake Ontario and the St. Lawrence River. The holistic monitoring and analysis allowed to better understand why contaminants are not decreasing in some cases with fish advisories continuing. The findings of the study will inform management actions to improve Lake Ontario's nearshore areas to achieve desired goals for fish consumption

P.D. Lorch, Cleveland Metroparks; M. App, S. Ochs, Great Lakes Data Watershed. **Great Lakes data deluge: Using abundant sensor data to inform recreation and manage watersheds**.

The important work of improving Great Lakes health, done upstream in watersheds, is informed by data from growing networks of sensors. The resulting data deluge decreases in value as its volume grows. The Great Lakes Data Watershed (GLDW) was designed to make water data useful to recreational users and mangers. It uses watersheds as a metaphor for aggregating data from sensors into higher level data streams. The Cleveland Metroparks dashboards included in GLDW (cmparks.gldw.org) demonstrates novel approaches to handling and presenting water data to maximize its value. We describe current and future uses of our dashboards. Data from many sources including the USGS, NDBC, sewer district, and the Cleveland Metroparks is presented on interactive dashboards to provide insight into watershed dynamics and water quality issues. GLDW is focused on improving the ways we manage, store, analyze, and use data to better manage our watersheds and ultimately, improve the health of the Great Lakes.

P.A. Loring, University of Guelph, Arrell Food Institute and the Department of Geography; H.L. Harrison, University of Guelph, Geography, Environment, and Geomatics; C. Robinson, University of Guelph, Department of Integrative Biology. **Bridging knowledge systems to steward biodiversity: linking local and traditional knowledge and eDNA**.

In recent years, great advances have been made in advancing and integrating natural and social science methods with local and traditional ecological knowledge (LTK) to explore ecosystem health and biodiversity. Environmental DNA (eDNA) is the latest addition to the research area, and has proved a robust and highly reproducible tool that community groups and management agencies can use to address data-deficiencies in freshwater systems. In this presentation we discuss the potential synoptic complementariness among LTK and eDNA, as well as the possible challenges to bridging across these very different ways of knowing. With a focus on transdisciplinarity, we present a framework for a community-engaged approach to assessing freshwater biodiversity and developing a sentinel surveillance system for ecosystem health in the Great Lakes region and beyond.

E.K. Lower, Michigan Sea Grant; R. Sturtevant, Michigan State University, Michigan Sea Grant; A.K. Elgin, NOAA Great Lakes Environmental Research Laboratory, Lake Michigan Field Station. **Alien Language: Reflections on the Rhetoric of Invasion Biology**.

Scientists, educators, and reporters often use a familiar set of military metaphors when talking about non-indigenous species, speaking of “fighting back against aquatic invaders,” “halting the spread of exotic alien species,” and “winning/losing the war on AIS,” among many others. While this language makes for a compelling narrative, it is often politically loaded, and may not be appropriate for use with all stakeholder groups. Drawing from best practices recommended by multidisciplinary texts, this presentation will analyze the use of loaded language and metaphors in the context of outreach and communications material about Great Lakes aquatic invasive species,

and provide alternative options and metaphors that science communicators might choose to use instead when discussing AIS with broader audiences.

M

S. MacIntyre, University of California Santa Barbara, Marine Science Institute. **Variability in Near-surface Turbulence in Lakes at Different Latitudes: Implications for Gas Transfer Velocities**.

Diel cycles of stratification and mixing are prevalent in the surface layer of lakes. Monin-Obukhov similarity theory (MOST) predicts increased rates of dissipation of turbulent kinetic energy (?) during heating with low winds and lesser enhancement of ? under low winds and cooling. By scaling ? using MOST, gas transfer velocities can be computed and used to compute fluxes. Using profiles of temperature-gradient microstructure, time series meteorology and temperature, we compare and contrast measured and calculated ? from tropical to arctic lakes. Results from tropical and arctic lakes show clear augmentation of near-surface ? for positive buoyancy flux (?+ heating) and light winds. ? was ~ 10 times higher during heating than cooling. Including the contribution of heating to increased dissipation rates at low winds and two dimensional processes at higher winds will lead to improved estimates of regional and global carbon budgets in large and small water bodies world-wide.

R. MacLellan-Hurd, ORISE, EPA - GLNPO; L.E. Burlakova, A.Y. Karatayev, SUNY Buffalo State College, Great Lakes Center; S.E. Daniel, SUNY Buffalo State, Great Lakes Center; A.E. Scofield, US Environmental Protection Agency, Great Lakes National Program Office; E.K. Hinchey Malloy, U.S. EPA, Great Lakes National Program Office. **Invasive dreissenids effects on sediment nutrient composition and other benthic organisms**.

The invasion of dreissenid mussels has resulted in changes to Great Lakes' ecosystem functions, including altered nutrient cycling. One way that dreissenid mussels recycle nutrients is through the production of biodeposits (feces and pseudofeces), and conventional thought is biodeposit production should result in higher sediment organic carbon in mussel-colonized areas. However, biodeposits could serve as a food source for bacteria and other benthic invertebrates, leading to lower organic carbon within the sediment due to high mineralization rates. To better understand the effects of the dreissenid invasion on benthic ecology, we use data collected in Lakes Michigan, Huron, and Ontario during recent Cooperative Science and Monitoring Initiative surveys to compare sediment nutrient concentrations and benthic community composition between low and high mussel density sites. Results show high mussel density regions did not differ or had lower nutrient concentrations than areas without mussels and had significantly higher densities of oligochaetes, potentially indicating more rapid nutrient regeneration driven by higher biological activity.

M.M. Mader, Grand Valley State University, Biology; C.R. Ruetz, Grand Valley State University, Annis Water Resources Institute; S. Woznicki, H. Kuhnle, Grand Valley State University. **Water quality and land cover in Lake Michigan drowned river mouths**.

Lake Michigan's drowned river mouth (DRM) systems are hydrologically unique due to their riverine and large-lake influences that create biologically diverse ecosystems. Serving as focal points for human development and the confluence of watershed impacts, development has directly altered DRM ecosystems. We sampled 12 DRMs and found that chlorophyll-*a* and total phosphorus (TP) concentrations increase in southern DRMs. Within DRMs, we found that TP concentrations are typically greatest near the river mouth and decrease closer to the outflow. We also found that

watershed human population density and agriculture were strong drivers of chlorophyll-*a* and TP. Our results support previous findings that land use drives chlorophyll-*a* and will be used to better understand the effects of development in DRMs. Our research demonstrates the impacts of land use and shoreline structure on DRM ecology, which will be useful to managers and researchers concerned with coastal habitats in Lake Michigan.

J.O. Manyala, Jaramogi Oginga Odinga University of Science and Technology, Natural Resource Management. **Application of Indigenous Knowledge on Fish Breeding Areas and Seasons in Lake Victoria, Kenya**.

Information obtained from the resident fishermen using questionnaires and available historical publications on Lake Victoria fisheries were used to arrive at closed areas and closed seasons. Both indigenous knowledge and scientifically documented data could produce adequate knowledge to validate the concept of closed areas and seasons for fishery in Lake Victoria, Kenya. River mouths and wetlands clearly featured as fish breeding ground. Breeding seasons could be closely mapped on to the annual two peak rainy seasons in March/April/May and September/October/November. Potamodromous fish species were confirmed to have synchronized movements upstream to breed mainly in the peak rainy seasons from both indigenous knowledge and literature. Other evidences, which featured particularly from indigenous knowledge, were the presence of many fish fry, fingerlings and eggs. This study resulted in gazettement of 98 fish breeding grounds and declaration of breeding seasons each year in the Lake Victoria (Kenya), vide Kenya Gazette Notice No. 7565. Indigenous fisheries management approaches are overridden by socio-economic needs.

E.C. Marano, Ellary Marano, School for Environment Sustainability; D.B. Bunnell, USGS Great Lakes Science Center, Great Lakes Science Center; K.M. Alofs, University of Michigan, School of Environment and Sustainability; P.M. Armenio, USGS Great Lakes Science Center. **Great Lakes larval fish diets in a post-dreissenid invasion era**.

Following the invasion of Dreissenid mussels in the Great Lakes, the zooplankton community has become dominated in biomass by calanoid copepods and in number by Dreissenid veligers (larval mussels). This has altered the prey available to larval fish, a life stage where variation in survival has a disproportionate effect on adult abundances. To assess the importance of veligers in larval diets, we estimated the diet proportion and selectivity for three species collected from Lake Huron in 2017: burbot (Lota lota), rainbow smelt (Osmerus mordax), and bloater (Coregonus hoyi). Results indicate that veligers are rarely selected by rainbow smelt but are more common in the diets of bloater and even more so in burbot. Further, smaller burbot had higher instances of veliger consumption than larger burbot, indicating that veligers could be an important prey item while fish are gape limited and unable to consume larger zooplankton.

A.M. Marcarelli, Michigan Technological University, Biological Sciences; J. Anderson, Michigan Technological University, Great Lakes Research Center; C.N. Brooks, Michigan Technological University, Michigan Tech Research Institute; C. Huckins, Michigan Technological University, Biological Sciences. **Autonomous and remotely-operated surveys of nearshore river plumes in Lake Superior**.

Our goal was to quantify the extent and volume of river plumes in nearshore Lake Superior using water quality sensors deployed on an autonomous underwater vehicle (AUV) along with aerial natural color and multispectral imagery collected from an unmanned aerial vehicle (UAV). We sampled two river plumes (Salmon Trout and Iron Rivers) in mid-July 2019, when plumes should be small and warm, maximizing likelihood of detection. At each river mouth we deployed 8-10 marker buoys in approx. 500 x 300 m grids where we measured water characteristics (nutrients, temperature, light penetration) and deployed the AUV and UAV. In both cases, this sampling design captured

river plumes from mouths to where the influence of river water was no longer detectable in the lake bays. For example, the UAV-based aerial imagery from the Iron River suggests that plume boundaries can be determined based on water color, and was corroborated by gradients of colored dissolved organic matter collected with the AUV. Merging these datasets will allow us to generate three-dimensional estimates of plume extent, which is essential to quantify near-shore influence and transport of riverine inputs.

K. Marin, Concordia U., Biology; P. MacLeod, Cree Nation of Mistissini; D. Fraser, Concordia U., Biology. **Long-standing, collaborative knowledge leads to community-based conservation: Mistassini fisheries**.

The Cree Nation of Mistissini and Concordia University have a long-standing relationship of bridging Indigenous and scientific knowledge for community-based fisheries conservation. We have combined Indigenous knowledge with genomic, morphological and ecological data on several freshwater fishes for management decision-making in Mistassini Lake. It is Quebec's largest natural lake and supports both local subsistence and recreational fisheries. By uniting knowledge systems, we have been able to infer local populations dynamics, temporal and seasonal movements, harvesting trends and complement management recommendations with Indigenous fisher concerns. The collaborative spirit of our partnership has led to the development of baseline data, multi-year studies, interdisciplinary publications and community-based monitoring projects. Our latest research - part of the largescale initiative *FISHES (Fostering Indigenous Small-scale fisheries for Health, Economy and food Security)* will focus on enhancing the co-evolution of knowledge to address critical challenges and opportunities related to local food security and sustainable fisheries.

L. Marshall, Cherokee Federal at NOAA GLERL; A.J. VanderWoude, S. Ruberg, NOAA GLERL; Z. Haslick, J. Sullivan, Aerial Associates Photography Inc. **Integration of Hyperspectral Camera System for Crewed Flyovers**.

Dynamic harmful algal blooms (HABs) are a persistent concern in the western basin of Lake Erie, for both human health and the health of the economy. Routine monitoring efforts track HABs with satellite imagery but consistent cloud-free coverage is not available. For the past six years, the NOAA's Great Lake Research Environmental Laboratory (GLERL) supplemented satellite imagery with crewed hyperspectral camera flyovers. NOAA GLERL's Resonon Pika II hyperspectral camera captures images in the 400-900nm spectral range, 240 bands, and 17.6 degree field of view and the newer Resonon Pika L, increases capabilities and utilizes a dual GPS. The Resonon Pika L requires lengthy troubleshooting to integrate with the Cessna 210 and provide sufficient power to the system. Both cameras were flown successively to compare differences in installation and quality of the data. In the near future, the Pika L will be flown routinely on an uncrewed aircraft for rapid response efforts and will be the standard camera flown on the weekly crewed flights over Lake Erie.

C. Marshall, Cornell University, Dept. of Natural Resources and the Environment; J.K. Connolly, Cornell Biological Field Station, Department of Natural Resources and the Environment; P. Boynton, Cornell Biological Field Station, Department of Natural Resources; J.M. Watkins, L. Rudstam, Cornell University, Natural Resources. **Seasonal Rotifer Community Trends: Lake Ontario CSMI 2018**.

Rotifera are among the smallest metazoans on earth, but they can still be a large component of freshwater communities. We present data on Lake Ontario's rotifers using samples collected lakewide as part of a bi-national inter-agency effort known as the 2018 Cooperative Science and Monitoring Initiative (CSMI), including data on seasonal trends and spatial patterns of community composition, density, and biomass. Both rotifer density and biomass peaked with surface water temperature in August at ~1500 #/Liter and ~3000 ug/m3, respectively. From April-June, *Synchaeta*

sp. dominated the overall rotifer abundance, and then decreased to become the least abundant in late summer and fall. The genus *Keratella*had the opposite seasonal development, being the least abundant in the spring and most abundant from July-October. The abundance and biomass of rotifers is also related to that of copepods and cladocerans, the groups that are typically emphasized in Lake Ontario zooplankton trends.

P.J. Martin, Aqua Insight Inc. **Refined Consumptive Use Calculation for High Volume Permits**.

One of the key elements toward improving water quantity management within the Great Lakes is to enhance our ability to understand consumptive use volumes. Ontario efforts toward obtaining improved quantification of consumptive use have been focused on high volume (e.g., > 19 MLD) Permits to Take Water (PTTWs), where approximations using standard consumptive use coefficients are considered suspect. For these permits, more rigorous consumptive use evaluation approaches were tested. Independent approaches were developed for: 1) Municipal, 2) Agricultural, and 3) Industrial - Commercial - Institutional. These subdivisions reflect independent considerations such as seasonal changes in demand that impact when the 90-day maximum demand occurs. The refined calculations utilize readily available data to complete "Site Specific Consumptive Use" calculations. This presentation will outline the research conducted in Ontario and highlight key considerations for refined CU calculation.

G. Martin, Carleton University; W. Bezha, Délı̨nę Got'ı̨nę Government; L. Chavarie, Norwegian University of Life Sciences, Faculty of Environmental Sciences and Natural Resource Management; J. Chapman, Carleton University, School of Public Policy and Administration; D. Simmons, ʔehdzo Got'ı̨nę Gots'ę́ Nákedı (Sahtú Renewable Resources Board); K. Howland, Y. Janjua, Fisheries and Oceans Canada; E. Reeves, Délı̨nę ʔehdzo Got'ı̨nę (Renewable Resources Council); R. Hammitt, S. Schott, Carleton University, School of Public Policy and Administration. **FISHES: Fostering Indigenous Small-scale fisheries for Health, Economy, and food Security in Sahtú, NT**.

How can knowledge-co-evolution processes inform inclusive fisheries co-management and enhance food security, conservation, and socio-economic development in northern Indigenous community settings? Sahtú (Great Bear Lake) plays a vital role in the local culture, food security, and economy of the Dene community of Délı̨nę and the broader Sahtú Region. The subsistence fishery from this relatively pristine Arctic lake is a dietary staple and is essential for the community's cultural and spiritual connection to the land and water. Long-term monitoring by Fisheries and Oceans Canada provides valuable stock information from the past 20 years. The Genome Canada FISHES project is bringing together Délı̨nę Got'ı̨nę knowledge holders and scientists to progress both Dene naowerə́ (knowledge) and science in support of knowledge co-evolution as a basis for planning in the context of environmental change. Together the partners will present the history of their collaboration, their approach to knowledge-sharing with the Délı̨nę ʔekwę́ hé Łue (Caribou and Fish) Working Group, and the project's next steps.

C. Masson, Trent University, School for the Study of Canada. **The global to local roles of a UNESCO Biosphere Reserve: Protecting, conserving and exploring Great Lakes ecosystems**.

Located on the north shore of Lake Erie, the UNESCO-designated Long Point Biosphere Reserve (LPBR) is a coastal sand spit formation extending 32 km into the central basin. This designated Ramsar site features a significant waterfowl staging and migratory stop-over area, and distinctive remnant 'Carolinian' forests. Several pilot ecological restoration projects are addressing local conservation issues and demonstrating innovative approaches to biodiversity threats across a

large wetland complex. These include efforts to eradicate invasive *Phragmites australis*, reduce wildlife road mortality, conserve and restore wetland and tall grass prairie habitats, and promote the reduction of agricultural run-off and plastics pollution – contributing to Great Lakes basin ecosystem protection. LPBR conservation and education programs integrate traditional ways of knowing and Indigenous peoples' perspectives in workshops and other fora. LPBR promotes sustainability by reconnecting people with nature.

C. Masson, Trent University, School for the Study of Canada. **Part One: Learning from our shared history to honour our responsibilities to future generations**.

Turtle Island, Bear Island to some and North America to others after Amerigo Vespucci, an early explorer who realized unlike Columbus that he was not on the shores of India but rather a continent new to most Europeans is where we all call home. But how did it all come to be? Through the making of treaties, came upon this land an understanding of co-governance. Much can be learned about movement to re-ignite the Indigenous peoples and Europeans agreement to share the land within the contextual guidance of the treaty but a desire to do what is right. This 40-minute workshop aims to bring people together in a "good way" to create a safe and meaningful space to break down barriers, ask questions and begin to build at understanding our shared responsibility for the protection of the land and waters. The first of two presentations will focus on the work that has been done. Educating some participants on initiatives that are being implemented at both the provincial and national stages.

C. Masson, Trent University, School for the Study of Canada. **Part Two: Learning from our shared history to honour our responsibilities to future generations**.

Practitioners are now looking to be guided by an acceptance of both legal systems in solemn ceremonies and coded in wampum belts along with recent domestic and international achievements leading to the contemporary establishment of Ethical Space. It is through Ethical Space that we are able to bring Indigenous and non-indigenous peoples together to heal the land and each other, craving the way for reconciliation for the next seven generations. This 40-minute workshop aims to bring people together in a "good way" to create a safe and meaningful space to break down barriers, ask questions and begin to build at understanding our shared responsibility for the protection of the land and waters. The second presentation will focus on some ways we can initiate balance upon the waters and land we share in order to ignite our work with the spirit of *djou djou aki* (Mother Earth) through the unity of our hearts and mind.

C. Masson, Trent University, School for the Study of Canada. **CanadaÃ¢â‚¬â„¢s Boreal Great Lakes: A Freshwater Biodiversity Case Study**.

Canada's boreal Great Lakes region spans over 36.5 million hectares, including 4.55 million hectares of dedicated parks and conservation reserves across Lake Superior, the St. Mary's River and Lake Huron's North Channel to southeast Georgian Bay, and the Ogoki and Long Lac diversions. In June 1999, Ontario's first land use strategy was finalized after extensive Lands for Life consultations. The Central Ontario planning area encompassed 45 million hectares where Crown land and commercial resources extraction dominate. Objectives were to complete Ontario's parks and protected areas system and meet forest industry needs. Together Ontario's Living Legacy and the Ontario Forest Accord (March 12, 1999) protected 12% of the planning area across 45% of the province. In 2017, the Environmental Commissioner of Ontario reported that Canada would not fulfill its international biodiversity commitments until Ontario exceeds Aichi Target 11 as the province constitutes 10.8% of the nation's land mass.

C. Masson, Trent University, School for the Study of Canada. **An Ethical Principles Research-to-Action Agenda**.

If the purpose of research is to derive benefits and contribute to knowledge, then ethical principles are core assumptions by which all else by proximity derives value and classification. An ethical principle is a statement, agreement or rationale that is true at all times and places. Ethical principles pertain to matters of jurisdictional review, the formulation of institutional policies and procedures, research team conduct, the treatment of human participants and sentient, biotic, aesthetic and material entities, and related phenomena. This analysis defines four guiding ethical dimensions or 'altitudes': oversight, organization, operation, and ownership or onus, located across five thematic areas of scientific inquiry: human-involved, nature/biodiversity, Indigenous peoples, qualitative methods and internet ICT research. Within the diversity and flexibility of research practices, the aim is to propose a multilevel, global-to-local approach for recognizing and resolving moral dilemmas.

C. May, The Nature Conservancy, Protecting Land & Water; B. Cardinale, Penn State University, Ecosystem Science & Management; D.R. Pearsall, The Nature Conservancy, Conservation Science; P. Doran, The Nature Conservancy Michigan Chapter. **Project Manager Perceptions of the Human Wellbeing Benefits from Great Lakes Restoration Efforts**.

Environmental restoration traditionally focuses on standard ecological indicators like water or habitat quality, species abundance, or vegetation cover to determine success. However, there is growing interest in how restoration may impact people and communities. Further, building the case for a restored ecosystem's contribution to public health, recreation, or happiness could help ensure public support in the future. Drawing from the Great Lakes Restoration Initiative's database of records, we engaged a sample of local project managers with survey research to document the inclusion of human wellbeing criteria. We found that half of the surveyed projects set a wellbeing goal, despite it not being required. In addition, almost 70% of those managers believed their project met those goals. These perceptions of positive impacts for both people and nature suggest that restoration transcends traditional measures of success and including wellbeing metrics would capture many "unseen" benefits.

S. Mbabazi, Ministry of Agriculture, Animal, Industry and Fisheries, Fisheries. **Flooding and its impacts on Lake Victoria fisheries, a case of Uganda**.

Flooding and related disasters are growing globally in both frequency and intensity. Lake Victoria recently faced record water levels. Here, we assessed impacts of floods to fisheries stakeholders along the chain through a rapid participatory assessment conducted between July and August 2020 in 15 districts of Lake Victoria with a total of 40 landing sites and 459 respondents. Results indicate a general displacement in fisher communities especially for those in a 200m radius of the lake shores. Average fish quantities landed had reduced at the sampled landings, with fishers dealing in small pelagics reporting a 20% increase in post-harvest losses. Traders reported an increase in fish marketing costs and reduction in fish exports. We recommended a fisheries augmentation fund to help fishers attain the recommended fishing gear, fish drying/processing facilities and develop alternative livelihoods. Government should invest in re-engineering weather resistant fish handling infrastructure.

K. McCabe, H. Anderson, A. Burtner, University of Michigan, Cooperative Institute for Great Lakes Research (CIGLR); C. Kitchens, University of Michigan; T.H. Johengen, University of Michigan, Cooperative Institute for Great Lakes Research (CIGLR); C.M. Godwin, University of Michigan, Cooperative Institute for Great Lakes Research. **A Reassessment of Phosphorus Distributions with Respect to Hypoxia in Lake Erie's Central Basin**.

Seasonal hypoxia in the central basin of Lake Erie is both a symptom and a source of phosphorus (P) loading to the lake. Hypoxia in the basin was first linked to release of P from the sediments in the 1960-1970s, but due to a lack of monitoring of P in the hypolimnion it is unclear whether these patterns remain similar 50 years later. As part of the 2019 CSMI we measured vertical distributions of total P and soluble reactive P before, during, and following hypoxia. We found elevated P during the late summer in the nearshore hypolimnion with the onset of anoxic conditions, which later spread across the deeper waters in September and resulted in elevated P concentrations throughout the water column after turnover. Our findings corroborate findings of recent incubation experiments and stress the importance of accounting for internal P loading in lakewide budgets.

C.P. McDonald, Michigan Technological University, Civil & Environmental Engineering; M.J. Sayers, K. Bosse, Michigan Technological University, Michigan Tech Research Institute.
Temperature and water column stability explain an algal bloom in the Keweenaw Waterway.

Portage Lake is a large mesotrophic lake located in the Keweenaw Waterway, which connects to Lake Superior. During the summer of 2020, a rare cyanobacterial bloom was documented in the lake, with nuisance levels reported along the western shoreline. Here we describe the in-lake and meteorological conditions leading up to and during the bloom, using a combination of monitoring buoy and satellite data. A period of unusually warm air temperatures caused a rapid increase in water temperature, which drove a period of increased productivity (reflected in chlorophyll and dissolved oxygen data). Subsequently, a period of sustained low winds resulted in an extremely stable water column immediately prior to the occurrence of the bloom. Remotely sensed surface chlorophyll data reveal lake-wide dynamics during this period, and highlight the spatial heterogeneity of algal biomass. These results suggest that incipient blooms can be predicted using parameters that are easily continuously monitored.

E. McKay, A. Huff, J. Zalusky, University of Minnesota-Duluth, Large Lakes Observatory; J. Li, The Hong Kong University of Science and Technology, Department of Ocean Science; S. Malkin, University of Maryland, Center for Environmental Science; S. Katsev, T. Ozersky, University of Minnesota-Duluth, Large Lakes Observatory. **Ecology of giant, filamentous, sulfur-oxidizing Thioploca bacteria in Great Lakes sediments**.

The giant thiotrophic bacteria *Thioploca* spp. form extensive mats in marine sediment and play important roles in marine nitrogen and sulfur cycling. *Thioploca* spp. are also found in freshwater sediment with ambient sulfate concentrations of only 10s μM, where their distribution, ecological role, and biogeochemical function is enigmatic. We studied the ecology of *Thioploca* at 33 sites in the Apostle Islands (L. Superior) and Green Bay (L. Michigan) across a range of depths, water column productivity, and sediment properties. Sediment samples were analyzed for *Thioploca* biomass and distribution, as well as for solid sediment and porewater chemistry. We found *Thioploca* in the Apostle Islands and Green Bay at high densities of up to 150 g/m^2 WW. *Thioploca* was most abundant in the top 10 cm of muddy, organic-rich sediments. We identify some of the predictors of *Thioploca* distribution and biomass, contributing to our understanding of their role in the geochemical cycling of the Great Lakes.

P. McKinney, ORISE, US EPA Office of Research and Development, CCTE/GLTED; T. Hollenhorst, US EPA, Great Lakes Toxicology and Ecology Division; B. Alsip, US EPA, Great Lakes National Program Office; S. Miller, J.C. Hoffman, US EPA, Great Lakes Toxicology and Ecology Division. **Autonomous glider-based observations for understanding Lake Erie hypoxia**.

In the Great Lakes, detecting and monitoring dissolved oxygen levels over regional scales typically depends on models that are informed by sparse point observations. As part of the 2019 Lake Erie CSMI, USEPA deployed an autonomous glider in the lake's central basin to monitor and characterize the hypoxia layer over a broad area (100's of km2). In addition to its dissolved oxygen sensor, the glider was outfitted with a CTD and optical sensors for measuring chlorophyll, CDOM and optical backscatter. We present observations of the thickness of the hypoxia layer and associated parameters gained over the three-week glider deployment and discuss the challenges and pitfalls encountered as well as opportunities for incorporating glider-based observations of hypoxia and other dynamic properties into water quality models.

K.R. McKnight, University of Wyoming, Zoology and Physiology; L. Shoemaker, University of Wyoming, Botany; R. Jackson, Department of Natural Resources, Cornell University; L. Rudstam, Cornell University, Natural Resources; T. Zorn, Michigan Department of Natural Resources, Marquette Fisheries Research Station; M. Hossain, Fisheries and Oceans Canada; D.G. Fielder, Michigan DNR, Alpena Fisheries Research Station; W.W. Fetzer, University of Wyoming, Zoology and Physiology. **Time-scale specific (a)synchrony between Walleye and Yellow Perch dynamics across the Great Lakes**.

Synchronous and compensatory dynamics between species are important factors driving the resilience of fisheries' productivity to environmental change. Across the Great Lakes, Walleye and Yellow Perch support important fisheries; however, differentiating the influence of biotic interactions and environmental conditions on population dynamics remains challenging. Here, we calculate time-scale specific variance ratios for populations from multiple locations to quantify the time scale at which population dynamics between these species are synchronous and compensatory. Preliminary results support our a priori hypothesis that populations exhibit long-term synchrony, while in the short-term, interactions between these two species tend to be compensatory. However, results are not consistent across populations, highlighting (a)synchrony between populations is likely context-dependent. We discuss the importance of management actions and other ecosystem changes to explain patterns across populations.

E. McKnight, University of Alberta. **Identifying challenges to - and recommendations for - reconciliation in environmental science research**.

Despite increasing awareness of, and expectations for, reconciliation in environmental science research, there remains a lack of understanding, guidance, and action. Respectful & sensitive discussion of challenges and strategies moving forward is needed. Here, I identify challenges to, and recommendations for, reconciliation in environmental science research, founded on my experience as a limnologist working in northern Canada. Some of these challenges include: a perception that environmental science is less relevant to reconciliation because it doesn't directly involve people as subjects; lack of understanding of Indigenous ways of knowing, being, and living; prioritizing quantitative results over relationship building; a colonial and science-biased western research agenda; lack of knowledge and education regarding how to respect different worldviews. Recommendations are based on respect, creativity, patience, and include: acceptance, equality, and education of Indigenous ways of knowing, being, living; fostering structural change to prioritize relationships and support for reconciliation; holding awareness of individual bias.

P. Meisenheimer, Anishinabek/Ontario Fisheries Resource Center. **Anishinabek/Ontario Fisheries Resource Centre: Key Learnings from the Two-Eyed Seeing Approach**.

The Anishinabek/Ontario Fisheries Resource Centre (A/OFRC) works with Anishinabek communities belonging to the Anishinabek Nation as represented by the Union of Ontario Indians. In this presentation, we will highlight some key projects and learnings from bridging Indigenous and

non-Indigenous knowledge systems to monitor Great Lakes ecosystems with First Nation communities. The A/OFRC's experience working with Indigenous knowledge systems in scientific/technical projects ranges from basic surveys for provision of information, to working with First Nations' administrators to develop tools for the collection of Indigenous knowledge with knowledge holders on the land. We will draw on A/OFRC projects, including assessment of a species at risk (name or lake sturgeon) and development of fish and wildlife management tools (moos or moose) to illustrate the opportunities and challenges inherent in such approaches.

A.D. Ostrowski, W. Midden, Bowling Green State University, Chemistry. **Alginate-iron hydrogels used in manure treatment fertilize crop growth**.

Polyuronic acids form hydrogels when mixed with iron (III) salts in aqueous solutions. The hydrogels promote flocculation of solids and bind phosphate (1.2 mg phosphate/g gel) and ammonia (0.7 mg ammonia/g gel) in dilute manure (727 ppm phosphate, 1420 ppm ammonia content) from a typical dairy Concentrated Animal Feeding Operation. This process can reduce the cost of transport of the nutrients in the manure by 20-40X and reduces the hydrological mobility of the nutrients when this material is applied to soil as fertilizer so more nutrient is retained in farm soil and less is lost to the watershed. The hydrogels have been characterized using scanning electron microscopy, thermogravimetric analysis, and Fourier-transform infrared spectroscopy. In greenhouse conditions, tomato plants fertilized with nutrient-loaded hydrogels exhibited similar growth of biomass and fruits as tomatoes fertilized with the same solution used to prepare the hydrogels, demonstrating fertilizer potential of the hydrogels.

W. Midden, Bowling Green State University, Chemistry. **A dewatering process that reduces nutrient loss from agricultural fields fertilized with CAFO manure**.

A three-step, low-cost process for separating agricultural nutrients and solids from water of dilute CAFO manure has been tested. It is designed to produce an environmentally sustainable, slow-release fertilizer that has lower hydrological nutrient mobility than untreated manure when applied to fields so that nutrient loss to the watershed is reduced. This fertilizer can be transported 20 times further because of the removal of water, so it can be affordably transported out of watersheds where there is insufficient land for application at agronomic rates. In the first year of a pilot-scale test, flow-weighted-mean concentrations of dissolved reactive phosphorus and total phosphorus in combined surface and subsurface runoff were significantly lower from fields amended with the processed manure than fields amended with untreated manure. Fields had been amended with amounts of manure that contained the same amount of total phosphorus. Crop yields were not significantly different.

Z.A. Migeni, African Center for Aquatic Research and Education. **Strengthening freshwater experts' collaboration for Improved Health of the African Great Lakes**.

The seven African Great Lakes support over 50 million people with food, water, and livelihoods. Each one is multijurisdictional, bordered by at least two countries, which often makes management, scientific inquiry, and policy development disparate and inconsistent. Due to the challenges of harmonizing lake management and scientific inquiry efforts across boundaries, the African Center for Aquatic Research and Education (ACARE) established a network of lake-specific advisory groups consisting of freshwater experts. Each advisory group consists of experts from the riparian countries surround their lake and engage in consistent, regular, and structured communications. This presentation will describe the advisory group process, highlight the benefits of the process, and present opportunities for global collaborations required to improve the health of the African Great Lakes. Key words: Multijurisdictional, African Great Lakes, Scientific Inquiry, Freshwater Experts

M.E. Miller, Michigan Technological University, Michigan Tech Research Institute; L. Bourgeau-Chavez, Michigan Technological University, Michigan Tech Research Inst.; M. Battaglia, Michigan Technological University, Michigan Tech Research Institute; G.A. Meadows, Michigan Technological University, Great Lakes Research Center; C.N. Brooks, Michigan Technological University, Michigan Tech Research Institute. **Mapping the bridge between land and lake by modeling wetland hydrological connectivity**.

Coastal wetlands are highly valued as they provide vital wildlife habitat, uptake nutrients that contribute to harmful algal blooms, and protect neighboring uplands and shorelines from flooding and erosion due to storm surges and high lake levels. To support the informed management of coastal resources we have developed an automated algorithm to identify wetlands that are hydrologically connected to the Laurentian Great Lakes. Using both earth observations and hydro-enforcement algorithms, we have mapped wetland connectivity at low, average, and high water levels in the Lower Peninsula of Michigan. Historical field observations were used to validate model results and efforts are currently underway to improve upon the model and expand predictions to Lake Superior.

E. Mimouni, St. Lawrence River Institute, Research; M.R. Twiss, Clarkson University, Department of Biology; J. Ridal, River Institute. **Multi-year assessment of scale-based patterns of phytoplankton fluorometry in the St. Lawrence River**.

Improved knowledge of the patterns and of the main drivers of water quality in large rivers supports assessment and management of priority ecosystem resources and enables development of early warning systems. We used an integrated approach to analyze an ecosystem research database of the St. Lawrence River where phytoplankon fluorometric variables at several scales are studied in order to identify strongest patterns and to identify their main drivers. A long and mostly uninterrupted dataset (the REASON Project) that covers a large temporal extent (over four years) was used to better understand the patterns of phytoplankton-dependent variables in the region of the Upper St. Lawrence River, especially those at larger scales. We show that algal-related fluorometric patterns in the region can be best understood as large, yearly-scale patterns that are driven by seasonal changes in water temperature over which smaller-scale patterns related to organic matter and weather variable are observed.

A. Molina-Moctezuma, K.L. Kapuscinski, A.H. Moerke, Lake Superior State University, Center for Freshwater Research and Education; E.F. Roseman, USGS-Great Lakes Science Center, Great Lakes Science Center. **Restoring connectivity in a Great Lakes connecting channel: challenges and lessons learned**.

Modifications to the Great Lakes connecting channels have resulted in alterations that destroy and disconnect critical habitat, including important rapids habitat. The St. Marys River, an important corridor of the Great Lakes, lost >50% of its historical rapids habitat over the past century, which resulted in changes to biological communities. In order to recover some of the lost rapids habitat, a science-based restoration project, the Little Rapids Restoration Project was carried out as a cooperative effort between multiple agencies and stakeholders. After restoration, target flows (0.24 m/s) to support lithophilic fishes were met or exceeded, the biological community shifted, and species of interest were documented spawning in the area. While the early biological responses have been positive, the long-term success of this restoration is uncertain due to challenges associated with invasive species (e.g., *Didymosphenia geminata*), changing water levels, and unknown time frames required for recolonization by periodic spawners like lake sturgeon.

J. Mouradian, Central Michigan University, Institute of Great Lakes Research and Department of Biology; D.R. Uzarski, University of Windsor, School of the Environment; D.G. Uzarski, Central

Michigan University, Institute of Great Lakes Research, CMUBS, and Department of Biology; D. Learman, Central Michigan University, Institute of Great Lakes Research and Department of Biology. **Light synthetic crude alters microbial communities in various Great Lake ecosystems**.

Utilization of hydrocarbons is essential to modern economies; however, their transport poses the risk of spills that can lead to environment degradation in Great Lake ecosystems. Previous work in marine environments has shown that select microbial communities become dominant after exposure, however, little is known about freshwater ecosystems. Thus, sediment and water samples were collected from three sites in northern Lake Michigan and the Straits of Mackinac and microcosm experiments were conducted with three treatments: control (no crude addition), addition of crude, and addition of crude and fertilizer. Hydrocarbon degradation byproducts, such as methane and ethane, were observed in the headspace of microcosm jars for treatments with light synthetic crude, and higher concentrations were found in samples amended with both crude and fertilizer. Microbial community structure changed in microcosms with crude. Further, the abundance of Proteobacteria, a phylum consisting of known hydrocarbon degraders, increased in treatments with crude. Together, these data suggest various freshwater microbial communities can degrade light synthetic crude.

M. Munawar, M.A. Fitzpatrick, H.A. Niblock, Fisheries and Oceans Canada, Great Lakes Laboratory for Fisheries and Aquatic Sciences. **Assessing decadal changes in primary and bacterial productivity in the Laurentian Great Lakes**.

Primary productivity is the energy generated by phytoplankton at the bottom of the food web that supports higher trophic levels including fish. Likewise, bacterial productivity can play a key role in energy exchange via the microbial loop. This presentation will compare longer term (10-15 years) trends in phytoplankton and bacterial productivity in Lakes Superior, Huron, Erie and Ontario. Summer mean primary productivity (mg C/m3/h) in Lakes Superior (1.1) and Ontario (5.4) has been relatively stable but has declined in Lake Huron (from 2.1 to 0.8) and doubled in Lake Erie (from 15 to 32) since the early 2000s. Picoplankton productivity increased in all of the lakes except Huron. By comparison, summer mean bacterial productivity in Lake Huron was stable (0.07 mg C/m3/h) whereas the other lakes all showed a substantial increase. This presentation will discuss changes in productivity at the base of the food web and consider the ecological implications.

J. Murray, The University of Toledo College of Medicine and Life Sciences. **Impact of Harmful Algal Blooms on the Water-Food-Climate-Health Nexus: An Update**.

The toxins present in Harmful Algal Blooms (HAB) present unique challenges in this Water-Food-Climate-Health Nexus. This session explores the contact of humans and animals with HAB toxins and their fate in living systems. Using the principles of exposure science, epidemiology and modern toxicology we endeavor to provide an overview of key aspects of this complex interaction and highlight the role that common HAB toxins such as microcystins have in the following four areas: 1) The Transmission of HAB toxins Via the Fish/Food-web and Related Health Effects 2) The Health Effects of Aerosolized HAB Toxins 3) The Chronic, Long-term Health Effects of HAB Toxins 4) The Health Effects of HAB Toxins on Livestock and Agriculture By understanding how various HAB toxins affect human and ecosystem health, we aim to form evidence based guidelines and preventative strategies for HAB toxin exposure, especially in at-risk patient populations.

M. Myers, T.E. Sasak, The University of Toledo, Department of Environmental Sciences; J. Bossenbroek, University of Toledo, Environmental Sciences; B. Schmidt, Ohio Department of Natural Resources; E. Weimer, DNR, Ohio; T. Crail, The University of Toledo, The Department of Environmental Sciences; C.M. Mayer, University of Toledo, Lake Erie Center, Environmental

Sciences. **When the wall comes crumblin' down: Newly available walleye habitat in the Sandusky River, OH**.

In 2018, the Ballville Dam was removed from the Sandusky River with the intent to connect previously unavailable suitable spawning habitat for sport fish such as walleye (Sander vitreus). Our study objective was to assess the amount and quality of newly available walleye spawning habitat using a spatially explicit habitat suitability index (HSI) model. To estimate habitat quality, we quantified substrate, water depth, and water velocity. Substrate and water depth were measured using a Humminbird 998C Side Imaging unit and manually. Water velocity was modeled with HEC-RAS software. Habitat characteristics were mapped as spatially explicit layers in ArcGIS and combined in an HSI to delineate good, moderate, and poor spawning areas throughout the river. The model indicates that there is suitable spawning habitat upstream of the former dam. However, no walleye were detected in standardized electrofishing sampling in the spring of 2020 upstream of the former dam. Therefore, a barrier may still exist, such as the man-made Ice Control Structures built prior to dam-removal, and natural shelfs, preventing walleye from accessing this newly available spawning habitat.

N

H. Nakiyende, National Fisheries Resources Research Institute, Uganda, Capture Fisheries and Biodiversity Conservation; A. Taabu-Munyaho, Lake Victoria Fisheries Organization, Administration; E. Jackson, Makerere University, Department of zoology, Entomology and Fisheries Sciences; L. Chapman, McGill University, Department of Biology; W. Nkalubo, National Fisheries Resources Research Institute, Capture Fisheries and Biodiversity Conservation; D. Mbabazi, Food and Agricultural Organization (FAO), Fisheries; E. Nduwayesu, NaFIRRI, Capture Fisheries and Biodiversity Conservation. **Emergence of light fishing and the socio-economic implications on the multi-species fisheries in Lake Albert**.

Until the 1980s, Lake Albert supported a multi-species commercial fishery dominated by large-bodied species; including *Lates niloticus, Alestes baremose* and the moon fishes. However, catch records reveal a shift to dominance of two small pelagic species; *Engraulicypris bredoi* and *Brycinus nurse* that emerged in early 2000s. Both species, harvested mainly using artificial light constitute > 60% of the catch estimated at 335,475 t and employ > 70% of the fishing community. Nonetheless, their contribution to human nutrition and economic revenue remains low (40%) due post-harvest losses from poor handling and processing. Light fishing has also existed amidst conflicts, that revolve on competition for fishing grounds, unregulated effort, and bulk by-catch of juveniles of large-bodied species. Evaluation of light fishing technologies is needed to guide sustainable management and harmonious co-existence in a multi-species setting, while improved post-harvest handling will increase economic value and human acceptability. **Key words**: **Key words**: *Small pelagic species, Light fisheries, Multi-species fishery, Sustainability*

D.B. Namuyiga, National Fisheries Resources Research Institute, Uganda, Innovations and Post-Harvest fisheries. **Economic and financial impact assessment: An application to Lake Victoria fisheries, Uganda**.

Lake Victoria is a key resource to the riparian communities and the government of Uganda. The most often documented contribution is on macro-economic analysis, measuring GDP and foreign earnings. However, this misses the contribution of the various fishing units to the lake's macro economic contribution. We used the Business-Model approach to collect data from fishers and their fishing units in 2018 through a cross-sectional survey across 23 landing sites. Results show an average national break-even quantity of 15,206kg, an average break-even price of USD2.1, break-

even sales of USD19011 and a pay-back period of 1.38 yrs. Profit margin was highest in Kalangala followed by Namayingo and negative in Masaka. The results represent key financial indicators at the fishing unit level, we however, recommend an upstream evaluation to cater for management cost recovery since there are recent declines in fish stocks and the government may not realize the level of taxation expected.

J.T. Ives, University of Windsor, Great Lakes Institute for Environmental Research; A. Nankabirwa, 1National Fisheries Resources Research Institute (NaFIRRI). **Algal communities of L. Victoria and small ponds in its basin and response to industrial pollution**.

We examined the potential of microalgae to reduce pollutants in wastewater, to potentially control industrial pollution in aquatic ecosystems. Microalgae were obtained from Lake Victoria and two other sources, and applied to raw and pre-treated industrial wastewater to determine survival of species under high nutrient conditions. Environmental parameters and chlorophyll a were determined daily, nutrients on every 3rd day and algae composition and abundance on the first and last day of the 7 day experiment. We saw a >80% reduction in ammonia and phosphates in all set ups, but nitrates were only reduced in raw wastewater. Species from Lake Victoria experienced a reduced richness (14 to 7), dominated by *Planktolyngbya limnetica*. From other sources, species reduced from 13 to 3, dominated by *Spirulina platensis*. The findings will help managers develop guidelines for permissible limits for N and P released in the environment, and use of some microalgae species in biological pre-treatment.

K.E. Natwora, University of Minnesota-Duluth; C. Sheik, University of Minnesota Duluth, Biology and Large Lakes Observatory. **Nitrogen fixation, physiological response of Lake Superior Dolichospermum under varying environments**.

Nitrogen fixation or diazotrophy is an important microbially mediated process that converts dinitrogen (N2) gas to ammonia (NH3) using the nitrogenase protein complex (Nif). Nitrogen fixation is a linchpin of the nitrogen cycle that re-mobilizes N lost to denitrification and anammox processes. Across the Laurentian Great Lakes (LGL) nitrogen fixation has been grossly understudied. We show that N-fixing microorganisms are ubiquitous across the LGL, and highly active during algal blooms. Using a N-fixing Dolichospermum, isolated from the Lake Superior bloom, we show that it is genetically similar genomes recovered from Lakes Erie and Ontario. Together this emphasizes the ecological heterogeneity of Dolichospermum, and suggests it is phenotypically plastic, as it can persist in a range of ecosystems. Thus, we sought to characterize the physiological response of N fixation in Dolichospermum to nutrient conditions similar the LGL, and show its variable response across nutrient conditions.

B. Nawrocki, Ontario Ministry of Natural Resources and Forestry; T.B. Johnson, Ontario Ministry of Natural Resources and Forestry, Glenora Fisheries Station; M.D. Rennie, Lakehead University, Biology; A.T. Fisk, University of Windsor, GLIER. **Food web structure of the Laurentian Great Lakes - a cross lake comparison**.

The Great Lakes are heterogeneous aquatic ecosystems differing in physical properties, productivity, and stress. We hypothesize these differences will generate lake-specific food web processes resulting in different trophic positions and transfer efficiency between taxa. Using a tissue collection representing fishes from different trophic guilds (n > 5,400), we used stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotopes to compare food web metrics among ecoregions (anthropogenic, embayment, inlet, open coastal, outlet) in four Great Lakes (Superior, Huron, Erie, Ontario). Absolute differences among lakes was large, however, after adjusting for baselines, isotopic niches were comparable. Within lakes, niche overlap among ecoregions was high for piscivores (>60%) and more variable for planktivores and invertivores (20-80%). We attributed these differences among

fish guilds to relative home range – large for piscivores, smaller for the other species / guilds. Intrinsic differences in lake properties must be addressed before comparing food webs to generate accurate indicators of status and progress toward management objectives.

A.K. Neubauer, Illinois-Indiana Sea Grant; S.E. Daniel, SUNY Buffalo State, Great Lakes Center; K.M. TePas, Illinois-Indiana Sea Grant. **Scientists to Students! Using Great Lakes video calls to connect with youth learners**.

Researchers have been visiting with students across the Great Lakes basin, all from the comfort of their homes and offices. Through the Scientists to Students! (S2S) Great Lakes Video Calls program, Illinois-Indiana Sea Grant virtually connects scientists from a range of agencies and academic institutions with classrooms (grades 5-12) to share their experiences working on current research projects and using scientific processes to monitor and protect the Great Lakes. These conversations help students improve their understanding of the Great Lakes and gain insight into what a career in science entails. It's also helped researchers workshop their presentation skills and learn to distill complex topics for younger audiences. Join this session to learn about the S2S program, hear testimonials from past participants, and find out how you, too, can ignite interest in science and the Great Lakes in young minds! We'll share best practices for conducting engaging video calls with classrooms.

M. Nevers, U.S. Geological Survey - Great Lakes Science Center, Lake Michigan Ecological Research Station; M. Evans, USGS, Great Lakes Science Center; M.E. Lewan, U.S. Geological Survey, Great Lakes Science Center; K.J. Przybyla-Kelly, USGS Great Lakes Science Center, Interior; D.A. Shively, Michigan State University; E. Wimmer, USGS - Great Lakes Science Center. **Assessing Cladophora growth in Lakes Michigan, Huron, Erie, and Ontario**.

The benthic green alga *Cladophora* sp. and an associated community of benthic and epiphytic algae can create nuisance conditions through prolific growth, oxygen depletion, shoreline washup, and promotion of bacterial growth. In support of binational management efforts, we assessed benthic algal biomass and growth-limiting factors at sentinel sites in Lakes Michigan, Huron, Erie, and Ontario. Benthic algal biomass patterns were explored relative to dreissenid mussel abundance, nutrient availability, temperature, and light penetration. Dreissenid mussel abundance across lakes and depths was also explored. Vertical nutrient distribution indicated benthic nutrient sources or accumulation. Results from 2018-2019 and limited, preliminary 2020 results are presented for Lakes Michigan, Huron, and Erie. Overall results are consistent with the growing scientific consensus that dreissenid mussels have altered the nearshore Great Lakes ecosystem in ways that promote benthic algal growth.

H.A. Niblock, M. Munawar, M.A. Fitzpatrick, Fisheries and Oceans Canada, Great Lakes Laboratory for Fisheries and Aquatic Sciences; H.J. Kling, Algal Taxonomy & Ecology Inc., Algal taxonomy. **Assessing the microbial food web of Lake Winnipeg, 2003-2004**.

Phytoplankton and microbial loop samples (0-1m) were collected during lake wide surveys of Lake Winnipeg conducted in summer and fall 2003 and spring and summer 2004. Phytoplankton biomass was highly variable and highest in summer and fall (avg. 4 g m-3) and lowest in spring (avg. 1.6 g m-3). Biomass ranged between 0.16 g m-3 in 2003 summer in the southern basin to a high concentration of 21 g m-3 in fall of 2003 in northern basin due to blooms of *Oocystis gigas* and *Aphanizomenon flos-aquae*. Spring composition was dominated by Diatomeae and phytoflagellates. Summer was dominated by Cyanophyta, Diatomeae and Chlorophyta whereas during fall Cyanophyta and Diatomeae were prevalent. Microbial loop biomass (bacteria, picoplankton, heterotrophic nanoflagellates) averaged ~0.5 g m-3 for the entire sampling period ranging between 0.21 g m-3 in 2004 to 2.3 g m-3 in 2003 during summer. Patterns in distribution will be explored.

J. Nicholas, nicholas-h2o. **Cumulative Impact Assessment of Withdrawals, Consumptive Uses, and Diversions**.

The Great Lakes-St. Lawrence River Basin Sustainable Water Resources Compact and commit the states and provinces to assess the cumulative impacts of Withdrawals, Consumptive Uses and Diversions of Water from the Great Lakes. This assessment is conducted for each Great Lake, the upper portion of the St. Lawrence River, and the entire Basin at least every 5 years. The assessment is completed using data entered by states and provinces into the Great Lakes Regional Water Use Database. These data are compared to other fluxes into and out of the Basin, including precipitation, runoff, and evaporation. Uncertainty and research needs are also considered. The most recent assessment for 2011-2015 showed that the cumulative impact of diversions and consumptive uses was a net gain of 1492 cfs for Basin. The assessment for 2016-2020 will be completed in 2022.

S. Nolan, C. Donaldson, University of Windsor, Integrative Biology; C.M. Febria, University of Windsor, Great Lakes Inst. for Env. Research (GLIER) & Dept. of Integrative Biology. **Stories are Data, too! Delivering Science with Impact from the Healthy Headwaters Lab's Storyteller Initiative**.

What does it mean to deliver science with impact? Generally, it is quantitative scientific approaches that are revered however in many contexts and cultures, scientific knowledge is transferred across time and space through storytelling. Drawing on multiple ways of knowing, a global #KindnessInScience movement, Canada's Truth and Reconciliation Calls to Action, and the Dimensions Charter for advancing just, equitable, inclusive and diverse approaches to research excellence and impact, the Healthy Headwaters Lab created a position of a Lab Storyteller. The role of our Storyteller was to listen, learn, connect and generate an authentic communications strategy. Here we share insights from a pilot teaching and learning grant, and present metrics that both challenge and complement traditional notions of research impact and excellence. We share practical tips from this experience that can be transferrable across a range of contexts in the Great Lakes and beyond.

M. Notaro, University of Wisconsin-Madison, Nelson Institute Center for Climatic Research; Y. Zhong, University of Wisconsin-Madison; P. Xue, Michigan Technological University, Civil & Environmental Engineering; C. Peters-Lidard, C. Cruz, E. Kemp, NASA Goddard Space Flight Center; D. Kristovich, University of Illinois at Urbana-Champaign; M. Kulie, NOAA/NESDIS/STAR/ASPB; J. Wang, University of Illinois at Urbana-Champaign; C. Huang, Michigan Technological University, Civil & Environmental Engineering; S. Vavrus, University of Wisconsin-Madison; L. Briley, Great Lakes Integrated Sciences and Assessment. **Performance of the NU-WRF Regional Climate Model in the Great Lakes Region**.

There is a need to assess the current state of climate models in terms of their performance across the Great Lakes region and develop the next generation of high-resolution regional climate models (RCMs) to address complex limnological processes and lake-atmosphere interactions. Here, we focus on the generation and analysis of an ensemble of 3-km NU-WRF simulations. The study aims to identify the model's strengths and weaknesses; optimal configuration for the region; and the simulated impacts of different physics parameterizations, 1D lake model coupling, time-variant lake-surface temperatures, and spectral nudging. Several biases are identified in the cold-season simulations, including an atmospheric cold bias that is amplified by coupling to a 1D lake model but diminished by applying the Morrison microphysics scheme, an excess precipitation bias, excessive and overly persistent lake ice cover, and insufficient evaporation over Superior/Huron. The research team is currently addressing these limitations by coupling NU-WRF to a 3D lake model in support of the next generation of RCMs for the Great Lakes Basin.

S.A. Nummer, University of Toledo, Environmental Sciences; S.S. Qian, University of Toledo, Department of Environmental Sciences; L. Mason, NOAA, Great Lakes Environmental Research Laboratory. **Spatial and Temporal Trends in Great Lakes Ice Cover Duration in Response to Climate Change**.

Global average temperatures were relatively stable until the recent upward climb, a pattern described by Mann et al (1999) as a hockey-stick model, which consists of two line-segments (with the x-axis as time and temperature as the y-axis) meeting at a single changepoint to describe this trend. Research has shown that the hockey-stick model can also describe phenological variables that respond to temperature. This change in temperature impacts the ice coverage of important freshwater systems, which in turn, and affects the associated biodiversity. We apply the hockey-stick model to Great Lakes ice coverage data under a Bayesian hierarchical modeling framework to better quantify the time when the ice cover duration started to decline, thereby better quantifying the rate of decline. The Bayesian hierarchical model also stratifies the five Great Lakes into 17 sub-basins to evaluate the spatial trends.

O

J. Olson, FLOW: For Love of Water. **WITHDRAWN: A Framework for Great Lakes-St. Lawrence River Basin Public Trust Protection**.

In the 21st century, the overarching principles of The Commons and the Public Trust Doctrine provide flexible and time-tested frameworks for achieving global-to-local biodiversity goals for the protection and conservation of the Great Lakes–St. Lawrence River basin ecosystem, as per international agreements.

J.D. Ortiz, Kent State University, Dept. of Geology. **Spectral decomposition by VPCA using Google Earth Engine: Great Lakes and other locations**.

A fundamental challenge facing the Great Lakes and water bodies around the work is the growing threat of harmful algal blooms. Monitoring is challenging because of the episodic nature of these blooms. Chl a estimation alone is inadequate because all major groups of algae and cyanobacteria contain that primary pigment. Flexible algorithms that can be used with a range of hardware and which can differentiate between various algal group allows water managers to assess threats quickly and respond to threats to drinking water efficiently. Varimax-rotated principal component analysis meets those objectives. The method can be used with handheld, aerial or orbital sensors, providing flexibility for use at different scales in different environments. VPCA has now been ported to Google Earth Engine, increasing its effectiveness by providing access to the power of cloud computing and entire remote sensing catalogs. The method is well suited for incorporation to into smart monitoring systems.

W.F. Otte, Northern Michigan University, Dept. Biology; S. Sitar, Michigan DNR; D.L. Yule, U.S. Geological Survey Great Lakes Science Center; C.R. Bronte, US Fish and Wildlife Service; H. Swanson, University of Waterloo, Dept. Biology; B. Gerig, Northern Michigan University, Biology. **Diet similarity and trophic overlap of lean and Siscowet lake trout morphotypes across ontogenies**.

Here we investigate the diet similarity and isotopic niche overlap of juvenile Lean and Siscowet Lake Trout (Salvelinus namaycush) across six regions of Lake Superior. Diet composition was established through gut content analyses. Stable isotopes of δ15 N, δ13 C, and δ34 S were used to ascertain food web position and estimate the degree of niche overlap between the two morphs. Somatic growth, as a factor of density dependence, was characterized by fitting Von Bertelannfy

Growth functions and comparing among morphotypes and across regions to determine the impact of any overlap. Results of the diet analysis show Siscowet have boarder diet composition relative to Leans. However, stable isotopes depict little difference in base of production and suggest a high degree of the Lean niche falls within that of Siscowet. In some ecoregions, Siscowet undergo a shift in δ15 N and δ34 S at 300mm reflecting increased consumption of profundal prey. In these same regions, Leans have greater estimates of the L∞ parameter. This suggests the observed overlap in these regions may not matter as Siscowet appear to be feeding on similar prey items at greater depths.

P.A. Owl, Sagamok Anishnawbek First Nation. **Seeking Balance: Natural Law and Great Lakes Anishinaabe**.

First Nations peoples have a unique relationship with the lands and waters of the Great Lakes. The roots of the Anishinaabe lifeworld is *Ogichiinaakonige*, or the Great Spirit Law governing animals, plants and all the elements of Mother Earth that sustain us. Creation stories illustrate the material world (ontology), and traditional ceremonial teachings (epistemology). *Inaakonigewin* is the Great Binding Law, where democratic governance through the clan system fosters harmony and reciprocity (rather than liberal justice). *Minobimaadiziwin* is living a good life through the relational logic of mutual aid (as opposed to contract and consent), where the constitutional order is not individual autonomy, but interdependence. Great Lakes waters define Native Nations. Yet, Anishinaabe historically have had few legal remedies against environmental polluters and resource extractors, or the legal power to protect biodiversity and promote ecological restoration in their traditional territories.

P

A. Pamajewong, Shawanaga First Nation, Hatchery Operations. **Restoring Native Fish Populations: Developing a Community Based Walleye Program in Shawanaga First Nation**.

This presentation will discuss Shawanaga First Nation's community-based walleye program and its importance to the First Nation. Shawanaga operates a walleye hatchery at Shawanaga landing to support the walleye population and the traditional walleye fishery. Walleye fry are stocked every year and traditional harvest activities take place with involvement of youth, community members, and knowledge keepers. The community has plans to upgrade their existing facilities to rear walleye fingerlings and improve the survivability of the fish. In addition to stocking, there is also a community led monitoring program that tracks and assesses fish harvested by community members. We hope that this talk can inspire other communities to begin hatchery programs and restore native fish populations."

S.R. Parker, Parks Canada, Protected Areas Establishment & Conservation; L. Wenzel, E. Brody, National Oceanic and Atmospheric Administration; E. DiDonato, US National Park Service; J.M. Dettmers, M. Gaden, Great Lakes Fishery Commission; M. Thiess, Parks Canada, Ontario and Waterways; K. Hartley, Ontario Parks; C. Deloria, US Fish and Wildlife Service; J. Anderson, Environment and Climate Change Canada. **Building a Great Lakes Protected Areas Network**.

Within and along the coast of the Great Lakes, conservation-minded ambitions and actions have led to establishment of over 700 individual protected areas. However, despite their designation, these areas also remain vulnerable to the universal threats that drive biodiversity decline and loss. It's a challenging context, one that not only requires protected areas to be effectively and equitably managed, but to be most effective, also part of a well-connected, representative and integrated network. Representatives from several agencies, including NOAA, Parks Canada, US NPS, US FWS,

GLFC, Ontario Parks, and ECCC, have recently formed the Great Lakes Protected Areas Network (GLPAN) with the informal goal of serving as a binational partnership and community of practice for coastal and aquatic protected areas. This presentation will discuss the context and priorities for GLPAN, including protected area communications, ecological connectivity, and conservation at scale.

T. Patel, University of Windsor, Great Lakes Inst. for Env. Research (GLIER); C.G. Weisener, K.G. Drouillard, University of Windsor, Great Lakes Institute for Environmental Research. **Assessing methods-based differences in sediment phosphorus adsorption capacity (EPCo)**.

Agricultural phosphorus (P) loads are partially buffered by tributary sediments behaving as a source or sink for soluble-reactive phosphorus (SRP) in the water column. The equilibrium phosphorus concentration (EPC0) is one measure of the P-sorptive capacity of sediments. Studies that measure EPC0 apply the batch equilibrium method. However, both the sediment field sampling procedure and sample shaking during incubation disrupts fine-scale physico-chemical gradients of the sediments that can contribute error in the in-situ EPCo value. To address these concerns, an alternative method to measuring EPC0 is developed. A dynamic mesocosm system uses wide-bore sediment cores to collect relatively undisturbed sediment and a water interface. The interface water is then recirculated through an external reservoir that is subject to external manipulation and sampling. This study presents an overview of the mesocosm design, its calibration, and a comparison to EPCo measurements determined by batch incubations. Calibration trials indicated time to steady state following initial SRP spikes are dependent on spiked-P amount and range from 1 to 7 d across multiple sediments. The system demonstrates repeatability in steady state SRP concentrations following multiple adsorption/desorption trials and low inter-core variation when sediment samples are collected from the same site compared to variation observed from different locations.

W. Paterson, Buffalo Niagara Riverkeeper. **RestoreCorps: Long-Term Shoreline Habitat Volunteer Stewardship Program**.

Buffalo Niagara Waterkeeper (BNW) and its partners have worked together to restore degraded shorelines throughout the Niagara River Watershed that enhance water quality, habitat integrity, and natural functions. Life thrives where the water meets the land and these “Living Shorelines” that have been established not only can provide environmental but also economic benefits for our community. Over the last ten years BNW has developed RestoreCorps, a robust volunteer network including highly trained individuals that can perform a range of activities required for proper long-term care of "Living Shorelines". This program of dedicated citizens is a cost-effective solution for long-term stewardship. Not only does this program provide the essential service of maintaining the sites, but it empowers citizens to take ownership over these spaces by taking responsibility to preserve environmental resources.

G. Paterson, Michigan Technological University, Great Lakes Research Center; S. Rush, Dept. of Wildlife, Fisheries and Aquaculture, Mississippi State University; M.T. Arts, Ryerson University; K.G. Drouillard, University of Windsor, Great Lakes Institute for Environmental Research; T. Johnson, Ontario Ministry of Natural Resources; B.F. Lantry, U.S.G.S., Lake Ontario Bio Station; C. Hebert, D. McGoldrick, Environment and Climate Change Canada; S. Backus, Environment and Climate Change Canada, Great Lakes Water Quality Monitoring; A.T. Fisk, University of Windsor, GLIER. **From pelagic to benthic: a rewiring of the Lake Ontario food-web**.

In this study, stable isotope and fatty acid ecological tracers were used to investigate temporal changes in the contributions of pelagic vs. benthic resource pathways for Lake Ontario fish including Lake Trout, Alewife, Rainbow Smelt, and Slimy Sculpin from 1992 - 2008. During this

period, tracer profiles for Lake Ontario prey fish demonstrated a convergence that was indicative of a redirection of pelagic carbon through benthic pathways and increased temporal similarity of these ecological tracer profiles among these prey fish. Similarly, mixing model analyses demonstrated an almost complete transition from 1992 - 2008 for Lake Trout from primary support from pelagic carbon resources to predominantly benthic processed carbon. This redirection of carbon resources in Lake Ontario emphasizes the role of dreissenid mussels as ecosystem engineers in aquatic food webs and their capacity to rewire trophic interactions that have may have cascading consequences for Great Lakes fisheries.

R.L. Paulsen, Pallas Educational Consulting and Associates. **Creating Space for Synergistic Relationships: Two-Eyed Seeing**.

The focus of this presentation is on the meeting place where Indigenous and non-Indigenous ways of knowing, understanding, and interacting is equitable, respectful, and in balance of *intercultural*, as opposed to cross-cultural, ontologies. 'Indigenous' and 'non-Indigenous' references are broad, therefore Manitoulin Island, Ontario (Lake Huron/Georgian Bay) is the site for this presentation although the content is relevant across Canada and internationally. Focusing on one location gives us a manageable context for our discussion and in turn, supports being able to transfer the content to practical applications, such as advancing collective knowledge, improving working and personal relationship dynamics, and policy development.

D.R. Pearsall, The Nature Conservancy, Conservation Science; S. Lishawa, Loyola University Chicago; E. Dunton, US Fish and Wildlife Service, Shiawassee National Widlife Refuge; A.M. Monks, Loyola University Chicago; M. Herbert, The Nature Conservancy; C. May, The Nature Conservancy, Protecting Land & Water; A. Verdeja, The Nature Conservancy; D. Albert, Oregon State University; W. Fink, J. Ross, Michigan State University. **Improving wetlands, soil health and water quality through invasive plant harvest and biomass use**.

Since 2016, TNC and partners have examined whether harvesting invasive cattails from a managed wetland improves wetland condition and habitat value and tested whether using the harvested biomass as a soil amendment improves soil health and crop yield. Harvesting resulted in more food resources for birds and lower abundance and biomass of invasive cattails while native plant diversity increased. Some nutrient ions became more available to wetland plants following harvest (NH4-N, P) and others less. Adding cattail biomass to crop soils increased soil organic matter and nutrients (NH4, PO4) and overall corn plant biomass in a lab setting, with inconclusive results in the field. Tracking the costs and benefits to wetland managers, farmers, and water quality stakeholders, we evaluated the feasibility of scaling the practice from a local field up to the Saginaw Bay Watershed to enable the "recycling" of nutrients back to the crop fields and improving water quality in streams and Saginaw Bay.

P.C. Peterson, S.S. Qian, University of Toledo, Department of Environmental Sciences; K. King, United States Department of Agriculture; T. Zhang, Agriculture and Agri-Food Canada. **WITHDRAWN: Hierarchical Bayesian model for regionalized agricultural conservation practice effectiveness**.

Agricultural conservation practices (ACPs) are an important win-win approach for jointly addressing agricultural productivity and environmental enhancement through mitigated runoff. The effectiveness of ACPs varies, not only by the type of ACP but also by location. Our model provides a ranked evaluation for some key ACPs in the Western Lake Erie Basin (WLEB) in terms of their effectiveness in reducing P and N loss. Our customized model downscales these results to the regional level by anchoring it with an informative, national-level prior distribution found by Nummer et al. (2018) and following the approach presented in Qian & Harmel (2016), both of

which were based on the USDA's Measured Annual Nutrient loads in Agricultural Environments database. We then incorporate recent edge-of-field data from the WLEB watershed to quantify and rank these ACPs on their effectiveness of nutrient retention specific to conditions in the region. The shrinkage effect that is incorporated in the hierarchical Bayesian approach improves the estimation accuracy in comparison to non-Bayesian methods.

S. Phelps, J. Mathia, Environmental Consulting & Technology, Inc.; A. Fletcher, Earth Economics; C. Pastoria, University of Michigan. **Modeling the economic value of Great Lakes restoration through ecological linkages**.

A science-based approach that links management actions to economic outcomes provides a clear pathway for future investments in Great Lakes restoration. The Michigan Department of Environment, Great Lakes, and Energy (EGLE) spearheaded the development of a decision support tool that evaluates management actions by calculating the ecological and economic values of Area of Concern (AOC) restoration. Based on EGLE activities in AOCs, we modeled 10 management actions and simulated changes in ecological conditions. The change in conditions from pre- versus post-implementation were applied to modify final ecosystem goods and services and economic values, determined using the benefit transfer method. This approach yields a flexible model for manager and decision-maker use, filling a critical data gap for EGLE that is shared by communities around North America that lack sufficient data with which to value ecosystem services and understand the full benefit of investments in restoration.

R. Pinto, University of Waterloo, Department of Earth and Environmental Sciences; H. Jarvie, University of Waterloo, Geography & Environmental Management; R. Brouwer, University of Waterloo, Department of Economics. **Methodological challenges in integrated hydro-economic modeling of water quality changes**.

There is a growing demand for integrated decision-support tools that couple water quality and socio-economic values associated with water uses requiring different water quality standards. This study builds upon an existing integrated hydro-economic model, originally developed by Environment and Climate Change Canada, to assess how changes in surface water quality influence the values attached by local water users to specific water uses based on the Water Quality Ladder (WQL). New in this study is the inclusion of non-use values in the WQL to capture environmental flow values. Relying on decades of water quality monitoring data, changes in water use are valued across the Grand River watershed in the Great Lakes basin. We discuss the challenges of coupling water quality and socio-economic data in an integrated watershed model, and highlight the potential of the model to better inform investment decisions in water quality improvements by assessing the associated non-market benefits.

P. Plisnier, University of Liège, Chemical Oceanography Unit; K.O. Obiero, Kenya Marine And Fisheries Research Institute, Research; A. Vodacek, Rochester Institute of Technology, Chester F. Carlson Center for Imaging Science; T.J. Lawrence, African Center for Aquatic Research and Education. **Toward a Multi-Lakes monitoring of African Great Lakes**.

The seven African Great Lakes (AGL) hold more than 28% of the volume of surface freshwater in the world, provide major services for over 50 million people, and are remarkable for their biodiversity. The AGL are under serious threats from climatic and anthropogenic pressures. To address these threats, decision-makers need comprehensive environmental data on which appropriate management measures may be based. Yet, for most of the AGL, there is presently no continuous, comparable, and harmonized monitoring. We describe a process to facilitate collaboration among more than 20 AGL research stations and a set of multidisciplinary scientists to create a comprehensive AGL-wide monitoring program. Our approach to monitoring will apply

various technologies and set standards for key water, fisheries, meteorology, erosion, biodiversity, and socio-economic indicators to inform lake managers and scientists on these critical large lakes.

A. Point, Clarkson University, Institute for a Sustainable Environment; T. Holsen, B. Crimmins, Clarkson University, Civil and Environmental Engineering; S. Fernando, Clarkson University, Center for Air Resources Engineering and Science. **Blood protein diversity as a potential driver for perfluoroalkyl acid trophodynamics in aquatic food webs**.

Perfluoroalkyl acid (PFAA) trophodynamic studies on aquatic food webs have generally produced inconsistent and inconclusive evidence of trophic magnification. Both controlled uptake experiments and peculiarities involving enhanced accumulation of PFAAs in lower trophic level organisms suggest that additional aspects beyond direct trophic transfer govern PFAA trophodynamics in these systems. PFAA accumulation, distribution, and elimination within biota depend on several protein-ligand interactions. In blood, PFAAs exist almost exclusively in protein complexes, mainly due to their relatively high affinity for serum albumin. Previous publications also describe diversity among fish species' blood proteins. Work in progress seeks to build on these findings by identifying the protein(s) expressing PFAA affinity within the blood of three Lake Ontario fish species (alewife (*Alosa pseudoharengus*), deepwater sculpin (*Myoxocephalus thompsonii*), and lake trout (*Salvelinus namaycush*)), and discerning whether the strength of PFAA affinity towards these blood proteins might contribute to the observed PFAA trophodynamics of this food web.

K.J. Przybyla-Kelly, USGS Great Lakes Science Center, Interior; M. Nevers, M. Byappanahalli, U.S. Geological Survey, Great Lakes Science Center, Lake Michigan Ecological Research Station; D.A. Shively, Michigan State University; A.M. Spoljaric, Michigan State University, Civil and Environmental Engineering; C.C. Morris, NPS. **Multiple studies on eDNA detection of invasive round goby in Lakes Michigan and Huron**.

Environmental DNA (eDNA) is sought for detecting invasive species, such as round goby (Neogobius melanostomus), but a thorough understanding of eDNA survival in the environment (e.g., effects of biological, physical, and chemical processes on persistence and detection) is needed to apply this technology. In multiple mesocosms and field surveys carried out in 2016 - 2019, we assessed round goby eDNA in Lakes Michigan and Huron, including shedding and decay rates, accumulation in sediment, lotic transport, and depth and temperature impacts on detection. We found that eDNA quantity was correlated with fish biomass, persisted in sediment for up to 150 days, and that decay rates were temperature dependent. In river mesocosm, eDNA was readily transported downstream, potentially for 50 km, but the signal disappeared soon after fish removal. In nearshore Lake Michigan, eDNA detection was consistent with mark-recapture results and showed that round goby may overwinter in these areas; eDNA was detected up to 80 m depth in Lake Huron, beyond trawl catches. eDNA holds great potential not only for future monitoring but also for evaluating species populations and behavior.

H.L. Purcell, University of Michigan CIGLR, CIGLR; T.H. Johengen, University of Michigan, Cooperative Institute for Great Lakes Research (CIGLR); S.R. Bickman, LightDeck Diagnostics. **Bridging the Gap Between Prototype and Market Ready: An Evaluation of MBio Gen 1 Rapid Toxin Detection Technology**.

Rapid detection and quantification of harmful algal bloom (HAB) toxins is vital for ensuring public safety and environmental health. Measurement approaches need to be accurate, and time/cost efficient. The Alliance for Coastal Technologies (ACT) evaluated the environmental performance characteristics of the prototype algal toxin detection field kit MBio HAB Toxin MC/CYN Gen 1 System. The evaluation was designed to demonstrate accuracy, ease of use, and reliability for field-based measurement of microcystin and cylindrospermopsin. Sample lysing and

analysis was performed in a two-step process with results in less than 30 minutes. The evaluation included both Lab and Field testing components with results compared against standard ELISA and LCMS estimations. Lab measurements in comparison to ELISA were within ± 1.9 µg/L and LCMS within ± 2.2 µg/L while field measurements were ± 2.1 and ± 1.5 µg/L respectively. The findings of the evaluation led MBio to improve their lysing system design and congener coverage. These changes were incorporated in the MBio Gen 2 System currently on the market.

M. Puzyreva, International Institute for Sustainable Development; E. Bussidor, Seal River Watershed initiative; G. Gunn, IISD Experimental Lakes Area. **Understanding the value of protected areas: case of the Seal River Watershed**.

The Seal River is one of the largest remaining free flowing (undammed) drainage basins in Canada and represents a valuable and rare habitat at the Boreal-Arctic transition.Five Indigenous communities have partnered in an alliance to permanently protect the watershed as an Indigenous Protected Area (IPA), which would contribute half-a-percent to Canada's protected areas targets. This 50,000 km^2 basin, drains into Hudson Bay and remains in a similar state as they were before European colonization. To assist the alliance in making the case for long-term protection we have conducted a preliminary assessment of ecosystem goods and services (EG&S), translating natural benefits—including carbon sequestration, wildlife habitat and tourism—into monetary terms. This allows local communities to make the case for conservation to audiences who do not share a connection to the region and integrate scientific and traditional ways of knowing into land and water stewardship.

R

C. Raudsepp-Hearne, J. Grimm, Wildlife Conservation Society Canada, Key Biodiversity Areas Program. **Key Biodiversity Areas to focus biodiversity conservation in Canada**.

Canada has high ambitions to protect much of its lands and waters over the coming decades, and must focus on protecting the right places. Among other values that deserve attention, such as biocultural values and ecosystem services, biodiversity should be a priority for conservation action. The Key Biodiversity Areas (KBA) tool is a standardized and globally recognized approach to identifying important areas for a range of biodiversity elements, including species and ecosystems. A multi-sector Canadian initiative to identify and map all KBAs in Canada began in 2019 as part of Pathway to Canada Target 1, building on data and knowledge from governments, academic institutions, conservation organizations and Indigenous partners. To date, we have identified over 200 KBAs across Canada, including a large set of freshwater KBAs recognized for fish, molluscs, plants and insects. KBAs provide a rigorous framework for bringing attention to the places that must be protected and stewarded, through enhanced management, formal protected areas or through other conservation measures.

A. Rayne, L. Collier-Robinson, C. Thoms, University of Canterbury, School of Biological Sciences; G. Byrnes, Te Kōhaka o Tūhaitara Trust; J. Hollows, KEEWAI; A. McIntosh, University of Canterbury, School of Biological Sciences; M. Ramsden, Environment Canterbury; M. Rupene, NgÃ„Â i Tahu Research Centre; P. Tamati-Elliffe, Te Nohoaka o Tukiauau Trust; T. Steeves, University of Canterbury, School of Biological Sciences. **Centring Indigenous knowledge systems to re-imagine conservation translocations**.

Conservation translocations that weave diverse ways of knowing and seeing promise to enhance species recovery and build ecosystem resilience. Yet, few published studies have been led or co-led by Indigenous Peoples; or consider how centring Indigenous knowledge systems can improve

conservation translocation outcomes. As Māori (Indigenous Peoples of Aotearoa New Zealand) and non-Māori researchers and practitioners working in partnership in Aotearoa New Zealand, we highlight the co-development of conservation translocations with Te Kōhaka o Tūhaitara and Te Nohoaka o Tukiauau Trusts. Here, we are weaving emerging genomic approaches with *mātauraka Māori* (Māori knowledge systems)—including customary practices, processes and language—to restore declining culturally significant freshwater species. We envisage more resilient biocultural heritage through the co-design of conservation translocations led or co-led by Indigenous researchers and communities around the world. *Note: Aisling Rayne, Levi Collier-Robinson and Channell Thoms will co-present.*

T. Redder, LimnoTech; M. Cooper, Central Michigan University; D.G. Uzarski, Central Michigan University, Institute of Great Lakes Research, CMUBS, and Department of Biology. **A Web-based Decision Support Tool for the Protection and Restoration of Great Lakes Coastal Wetlands**.

The *Coastal Wetland Decision Support Tool* (CWDST) is an interactive, web-based tool developed to support management decisions for protecting and restoring coastal wetlands throughout the Great Lakes. Based on a combination of geospatial analyses and biological metrics derived from the Coastal Wetland Monitoring Program (CWMP) datasets, the CWDST provides wetland site filtering and ranking tools that support rapid evaluation and cross-site comparisons of key ecological metrics within the context of local spatial attributes. More than 90 attributes are integrated into the tool, including Indices of Biotic Integrity; the presence of invasive species and structures; and surrounding land ownership, population, and land use. This presentation will demonstrate the value of the tool and highlight recent enhancements, including expanded coverage along the U.S. shoreline and the integration of tutorials to improve the accessibility of the tool to coastal managers and other stakeholders.

E. Redding, Gomez and Sullivan Engineers; T. DePriest, New York State Department of Environmental Conservation, Division of Fish and Wildlife Resources; L.H. Harper, Riveredge Associates; E. Sirianno, Buffalo Audubon Society. **Supporting the Buffalo-Niagara Common Tern Breeding Population**.

The Buffalo-Niagara region hosts a breeding population of Common Tern, a New York State Threatened species. Common Tern is threatened in part due to a lack of nesting habitat, and this population is largely dependent on intensely managed human-made sites in the Buffalo Harbor. However, these sites are not ideal, and in 2019, a powerful winter storm permanently destroyed a portion of the breakwater nesting area. Fortunately, Buffalo Audubon Society and New York State Department of Environmental Conservation had already recognized the need for more nesting habitat and an effort to supplement the Buffalo-Niagara nesting sites was in progress. As presented at IAGLR 2019, Gomez and Sullivan Engineers designed a tern nesting island with ideal nesting habitat in the Niagara River. The design drew on an understanding of Common Tern biology and took into account the potential for more frequent and intense storms as well as shifting average water levels. The island was built in 2020, and Commons Terns will arrive this spring. This island is expected to contribute to the resilience of the lower Great Lakes Common Tern population and the revival of the Niagara River ecosystem.

H.W. Reeves, U.S. Geological Survey, Upper Midwest Water Science Cetner. **Estimating impacts of groundwater withdrawals on streamflow**.

The Great Lakes-St. Lawrence River Basin compact stipulates that 'water withdrawals overall will not result in significant impacts to the waters and water dependent natural resources of the basin, determined on the basis of significant impacts to the physical, chemical, and biological integrity of source watersheds.' One challenge to water managers, therefore, is estimating the

potential streamflow depletion caused by existing, new, or increased groundwater withdrawals. A variety of approaches have been developed to meet this challenge including the use of analytical models, numerical models, and statistical analysis. We will review these approaches to invite discussion on their strengths and weaknesses, focusing on settings and types of management questions where each might be most appropriate.

H.B. Reid, McGill University, Department of Biology; A. Ricciardi, McGill University, School of Environment. **Interpopulation variation in thermal responses by the invasive round goby (Neogobius melanostomus)**.

The Great Lakes-St. Lawrence River system is being transformed through the combined effects of biological invasion and climate change. The round goby (*Neogobius melanostomus*) is established throughout the system, but its future distribution, local abundance and impacts will depend on population-level responses to climate warming. We measured feeding rates and thermal tolerance for gobies acclimated to current or projected future summer temperatures. Individuals were collected from four populations distributed along a latitudinal gradient from Lake Erie to the St. Lawrence River. Individuals from southern populations exhibited the highest feeding rates, and all populations consumed less food at elevated temperatures. Thermal tolerance increased with acclimation temperature at different rates across populations, except for a decline at the highest temperature for northern populations. Our results demonstrate the need for population-level thermal response data to inform risk assessment.

A.J. Reid, University of British Columbia, Institute for the Oceans and Fisheries. "**Two-Eyed Seeing": An Indigenous framework to transform fisheries research and management."**

Increasingly, fisheries researchers and managers seek or are compelled to "bridge" Indigenous knowledge systems with Western scientific approaches to understanding and governing fisheries. Here, we build an ethic of knowledge coexistence and complementarity in knowledge generation using Two-Eyed Seeing as a guiding framework. Two-Eyed Seeing (Etuaptmumk in Mi'kmaw) embraces "learning to see from one eye with the strengths of Indigenous knowledges and ways of knowing, and from the other eye with the strengths of mainstream knowledges and ways of knowing, and to use both these eyes together, for the benefit of all," as envisaged by Elder Dr. Albert Marshall. Here, we examine the notion of knowledge dichotomies and imperatives for knowledge coexistence and draw parallels between Two-Eyed Seeing and other analogous Indigenous frameworks from around the world. We explore its operationalization through three Canadian aquatic and fisheries case-studies and argue that Two-Eyed Seeing provides a pathway to a plural coexistence.

K.L. Reinl, Large Lakes Observatory, University of Minnesota Duluth; R.W. Sterner, University of Minnesota Duluth; T. Andersen, Department of Biology, University of Oslo; B.M. Lafrancois, National Park Service. **A cyanobacteria life cycle model for blooms in oligotrophic Lake Superior**.

Beginning in 2012, cyanobacterial blooms have been observed in Lake Superior with varying size and duration. All presented with akinetes, or resting stage cells, indicating that this may be an important mechanism in bloom formation and persistence; therefore, we developed a model that incorporates these life cycle stages. Our model considers two primary life cycle stages: vegetative and resting (akinetes), resulting in two biological equations which include growth, death, deposition, and transfer to/from the vegetative/akinete pools. Because NO3- concentrations in Lake Superior are very high relative to the phosphorus (P) pool, we assume P is limiting and thus, model the P pool alongside the vegetative and akinete pools, using P concentration to drive life cycle changes in the model. Preliminary results highlight the importance of P and light limitation, as well as their

concomitant effects, the role of watershed inputs of both nutrients and biological material, and horizontal advection from river inputs. This approach allows us to begin examining important drivers of blooms in Lake Superior and to identify where our current knowledge gaps are.

A. Renaguli, Clarkson University; S. Fernando, Clarkson University, Center for Air Resources Engineering and Science; P. Hopke, Clarkson University; T. Holsen, B. Crimmins, Clarkson University, Civil and Environmental Engineering. **Nontargeted screening of halogenated organic compounds in the Great Lakes fish**.

Fish have been used for decades as bioindicators for assessing toxic contaminants in the Great Lakes ecosystem. Routine environmental monitoring programs target predetermined compounds that do not reflect the complete exposure of chemicals to biota and do not provide the complete halogenated fingerprint of the biota. In the current work, a nontargeted screening method was developed using a 2-dimensional gas chromatograph coupled to a high resolution time-of-flight mass spectrometer (GC×GC-HR-ToF MS) and was applied to edible fish fillets and whole fish from the Great Lakes to characterize a more robust set of halogenated organic compound. Lake Ontario had the largest number of non-legacy halogenated organic components. Unknown chemical profiles were explored using correlation and clustering analyses to provide spatial and temporal information on unknowns and help identify persistent, emerging contaminants. Coupled with targeted chemical monitoring in the Great Lakes region chemical profiling provides a means to protect the region from known and unknown emerging contaminants of concern.

K.M. Reynolds, US Department of Agriculture, Forest Service Research; S. Paplanus, Mountain-View Business Group, LP; B. Miller, Rules of Thumb, Inc; P. Murphy, InfoHarvest, Inc.; C. Spenser, Logic Programming Associates, LTD; M. Druzdzel, BayesFusion, LLC. **Spatial decision support for environment analysis and planning with the EMDS system**.

The Ecosystem Management Decision Support (EMDS) system (http://emds.mountain-viewgroup.com/) is a spatial decision support (SDS) framework developed by the USDA Forest Service to support spatially enabled environmental analysis and planning. At version 8, EMDS runs as an add-in to ArcGIS Desktop, but an initial cloud-based service and open source GIS solutions will be available in 2021. The framework approach to SDS makes EMDS suitable for supporting a very wide range of complex, multi-scale SDS problems, because the questions and scales addressed as well as model and data requirements are all determined by EMDS application developers. The system uses workflow technology to manage the interoperability of four complementary analytical engines for logic-based or probabilistic reasoning, and strategic or tactical planning. The presentation presents a prototypical example of engine interoperability to support an adaptive management process for maintaining or restoring ecosystem integrity or resilience.

D.M. Robertson, D.A. Saad, U.S. Geological Survey, Upper Midwest Water Science Center. **Use of SPARROW model results to extrapolate limited monitored loads to large spatial areas**.

To evaluate the success of restoration efforts, continuous nutrient loading from the entire Great Lakes Basin in needed. Loading information, however, is only available from a limited number of sites. Here, we describe an approach to extrapolate loads estimated from consistent but limited monitoring programs using a surrogate-regression approach to the total loading from large areas, such as each Great Lake. This approach uses SPARROW ratios (ratios of nonpoint loads between monitoring tributaries and nearby unmonitored areas using published SPARROW models), annual point source inputs, and annual (or shorter term) monitored loads from ongoing monitoring programs (such as the Great Lakes Restoration Initiative Tributary Monitoring Network). The SPARROW-ratio approach incorporates the differences in point and non-point nutrient sources, watershed characteristics (such as soil types and land use) and spatial differences in runoff that occur

in non-monitored areas. Estimates from the SPARROW-ratio approach are compared with those of a previous approach that simply used unit-area yields to extrapolate to unmonitored areas.

J. Robson, University of Windsor, Great Lakes Inst. for Env. Research (GLIER). **WITHDRAWN: Benthic Macroinvertebrate Communities of Detroit River Wetlands**.

The Detroit River is a Great Lakes Area of Concern and has an ongoing history of anthropogenic stress impairing water quality. Beneficial uses of fish and wildlife habitat and benthic communities are both listed as impaired according to the Stage II Remedial Action Plan. This study seeks to examine benthic macroinvertebrate community between five wetlands from Canadian waters of the Detroit River and address whether compositions vary. Two of the wetlands are impacted by drainage of waters from tributaries dominated by urban or agriculture land uses. Within each wetland, sampling locations were distributed utilizing a stratified random sampling design. For the tributary impacted wetlands, strata were delineated to bound waters within the tributary, tributary/Detroit River mixing zone and waters upstream of the tributary input. Our data suggests moderate variation between each wetland and no significant variation with respects to tributary impacts.

D. Roman, National Geodetic Survey, NOAA/NOS; M. Veronneau, J. Crowley, Canadian Geodetic Survey, NRCan. **Lake Surface Topography from Water Gauging, GNSS Observations and Gravimetric Geopotential Models**.

The International Great Lakes Datum of 1985 (IGLD85) provides a common elevation reference surface for the Great Lakes and connecting waterways. Hydraulic Correctors (HC) are a necessary component of IGLD85. HC account for the apparent non-level water surfaces on the Lakes and caused by defects in the datum surface, glacial isostatic adjustment and persistent water topography. The International Great Lakes Datum of 2020 (IGLD2020) will replace the existing IGLD85 in 2025. IGLD2020 aims to eliminate the datum defect and better account for the time-varying GIA signal. This will still leave the requirement to develop models for any persistent Lake topography. Dynamic heights are determined from a common geopotential model derived from recent gravity observations. These heights are determined from GNSS observations at water level observation stations. In particular, Lake Superior and the Lake Michigan/Huron system appear to have topography of about 10 cm sloping upward from West to East.

M.D. Rowe, NOAA GLERL; E.J. Anderson, C. Stow, NOAA Great Lakes Environmental Research Laboratory; G. Lang, NOAA GLERL; J. Smith, Cooperative Institute for Great Lakes Research; D. Beletsky, University of Michigan, Cooperative Institute for Great Lakes Research; r. beletsky, University of Michigan, CIGLR; C.M. Godwin, University of Michigan, Cooperative Institute for Great Lakes Research; S. Moegling, Cleveland Water. **Simulation of 2019-20 Coastal Upwelling Events in a Lake Erie Hypoxia Forecast Model**.

In 2017-2020, we ran a hypoxia forecast model that generated a daily nowcast and forecast of three-dimensional fields of dissolved oxygen (DO) in Lake Erie. The goal of our five-year project is to develop a hypoxia forecast model that can serve public water systems in Lake Erie, and may be suitable for operational use at NOAA. The DO model was developed using the Finite Volume Community Ocean Model's General Ecological Module, and the hydrodynamic component was similar to NOAA's Lake Erie Operational Forecast System. Upwelling events occurred in August of 2019 and 2021 that caused sudden onset of hypoxic conditions and elevated manganese concentrations that required public water systems to take action to control manganese concentrations in treated water. These events were observed with real-time DO sensors (GLOS and LimnoTech) and with a DO sensor mooring array we deployed at coastal and offshore locations throughout the central basin. Advance notice of these events was provided to drinking water plants

through the NOAA GLERL website and by email communication. An assessment of model skill in representing these events will be presented.

S. Ruberg, A.J. VanderWoude, NOAA - GLERL; M.J. Sayers, R. Shuchman, Michigan Technological University, Michigan Tech Research Institute; G. Leshkevich, Great Lakes Env. Research Lab, NOAA; K. Bosse, Michigan Technological University, Michigan Tech Research Institute; G.L. Fahnenstiel, Michigan Tech Research Institute. **Great Lakes Water Quality and Primary Productivity**.

The Color Producing Agents Algorithm (CPA-A) uses SeaWIFS, MODIS, and MERIS satellite data to estimate concentrations of chlorophyll, dissolved organic carbon, and suspended minerals. The CPA-A was transitioned to the NOAA National Environmental Satellite, Data, and Information Service (NESDIS) CoastWatch Great Lakes node in 2018 and is currently being used for annual estimation of harmful algal bloom areal extent and time-series observations of water quality parameters going back to 1997. These satellite derived products are now being integrated with the EPA's Great Lakes National Program Office annual monitoring efforts providing relevant information supporting Great Lakes Water Quality Agreement reporting. In addition, a primary productivity model is being developed for CoastWatch to improve seasonal analysis capabilities. CoastWatch CPA-A products are continually being improved with ground truth from real-time buoys, weekly vessel-based lab sample and optical property collections, and from spatially relevant observations from autonomous vehicles.

C.R. Ruetz, Grand Valley State University, Annis Water Resources Institute; T. Hook, Purdue University, Department of Forestry and Natural Resources; D. Clapp, Michigan DNR Fisheries Division; G. Chorak, Montana State University, Plant Sciences Department; T. Senegal, Purdue University, Department of Forestry and Natural Resources; G. Bowen, University of Utah, Deparment of Goelogy and Geophysics. **Movement patterns of Yellow Perch in eastern Lake Michigan: implications for harvest**.

Drowned river mouths (DRMs) are a prominent feature of eastern Lake Michigan, providing transitional habitats between tributaries and the large lake. These habitats appear to be important in the spatial population structure of yellow perch (*Perca flavescens*). Genetic and isotope analyses suggest a complex pattern of habitat use and population structure. During summer, resident yellow perch in DRMs are genetically distinct from yellow perch in Lake Michigan. However, in late fall (and presumably over winter), a large proportion (potentially >75%) of yellow perch in profundal habitats of DRMs are genetically indistinguishable from Lake Michigan fish. Isotopic analyses convey a similar story; in late fall, the majority of adult yellow perch in profundal-DRM habitats spent the first months of their lives in Lake Michigan (based on analyses of otolith cores) and recently moved into DRMs (based on analyses of muscle tissue). From a management perspective, understanding the extent to which Lake Michigan yellow perch migrants are harvested in DRMs is critical for accurately estimating annual total harvest.

D. Russell, University of Maryland, Applied Mathematics & Statistics, and Scientific Computation Program; K. Ide, University of Maryland; M.J. Hoffman, Rochester Institute of Technology, School of Mathematical Sciences. **Developing a Data Assimilation System for Lake Erie Using the Local Ensemble Transform Kalman Filter**.

Data Assimilation (DA) is a process by which a model forecast of a physical system corrects course by re-initializing its model state, using information from both a prior forecast and recent observations. The current Lake Erie Operational Forecast System (LEOFS) uses real-time forcing data, but does not use this model re-initialization process. So far, research on DA for Lake Erie has focused on nudging, Optimal Interpolation (OI) and 3DVar methods. In this work, we explore the

use of another method, the Local Ensemble Transform Kalman Filter (LETKF), which uses an ensemble of forecasts to dynamically track forecast uncertainty, and has been shown to improve forecast skill in many systems. We test this method using an Observing System Simulation Experiment (OSSE), a tool in which one tries to reconstruct a (known) "nature" run using simulated, imperfect observations of that run. In our OSSE, we use satellite surface temperature observations to reconstruct both temperature and velocity.

E. Rutherford, NOAA Great Lakes Environmental Research Laboratory; M.D. Rowe, NOAA GLERL; A. Oppliger, Ohio State University; S. Prendergast, University of Michigan; D. Wells, Unversity of Michigan, CIGLR; H. Liu, University of Maryland Eastern Shore; K.M. Alofs, University of Michigan, School of Environment and Sustainability; D.B. Bunnell, USGS Great Lakes Science Center, Great Lakes Science Center; D.M. Mason, E.J. Anderson, NOAA, Great Lakes Environmental Research Laboratory; H.A. Vanderploeg, NOAA GLERL. **Modeling larval fish dispersal in Lake Huron and Michigan: implications for population connectivity**.

Hjort (1914) hypothesized that annual variation in fish recruitment is caused by currents dispersing eggs and larvae to productive or unproductive nursery areas. In Lake Michigan (LM) in 2015 and Lake Huron (LH) in 2017, we sampled larvae from April to August at nearshore, mid-depth and offshore sites, and predicted their hatch sites and dispersal using a 3-D hydrodynamics model (FVCOM) and a Lagrangian particle trajectory model. Model results were unexpected, and sensitive to assumptions of larvae vertical distribution. Backward projections of aged coregonine larvae from Thunder Bay LH and alewife larvae from southwestern LM suggested their hatch sites differed from known spawning sites. Forward projections of yellow perch larvae caught in Saginaw Bay LH suggested they were advected out of the bay to southwest LH. Our results can guide future studies of larval fish dispersal and inform how physical factors may affect fish population connectivity and recruitment.

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C. Salter, C.G. Weisener, University of Windsor, Great Lakes Institute for Environmental Research; J. Westrick, Wayne State University, Lumigen Instrument Center. **Investigating the Microbial Dynamics of Microcystin-LR Degradation in Lake Erie Sand**.

Microcystin hepatotoxins released during cyanobacterial blooms pose a human health risk in freshwater lakes worldwide. The microbial mlr gene operon has been identified to sequentially degrade microcystin-LR (MC-LR), however studies have argued against its involvement in observed MC degradation in Lake Erie, suggesting possible alternate, undetermined degradation pathways. To investigate the dynamics of the Lake Erie microbial community involved in MC-LR degradation in shoreline beach environments, a flow-through column experiment using sand from impacted sites was exposed to MC-LR spiked lake water. The MC-LR concentrations from biotic and abiotic (sterilized) sand columns were measured by LC-MS/MS. Complete elimination of MC-LR was observed within 21 h of contact time in the biotic columns, even after exposure to unnaturally high concentrations (max. dosage = 15.4 ppb). Metataxonomic analyses identified several core microbial taxa including Burkholderiaceae, Illumatobacteraceae, Pseudomonadaceae, and Rhodocyclaceae. The results suggest several critical species may be required for the most complete and effective degradation of MC-LR.

C. Sampson, Bkejwanong Walpole Island First Nation, Chief and Council. **Bkejwanong Walpole Island First Nation: Safeguarding Our Waters Through Sustainable Practices**.

Fish have always been an integral part of the cultural, spiritual and economic fabric of the Anishinaabe people of Bkejwanong Walpole Island First Nation (BWIFN). We harvested fish sustainably for millennia before outside governments restricted our access and gave away our fish to others who also polluted our waters. An example of the impact of mismanagement of the fishery resources by outside governments include the near extinction of nme (sturgeon) which were once plentiful. Before outsiders interfered in the management of our resources, BWIFN people respected everything we harvested from the waters and always made use of all parts of the fish we harvested: the flesh and roe for food, the skin for containers and the oil for paint and medicine. Our aim is to re-establish Anishinaabe governance over our water and our fishery resource so that we may once again nurture and harvest nme and other aquatic beings within our waters.

Z. Almquist, M.J. Sayers, K. Bosse, Michigan Technological University, Michigan Tech Research Institute; S. Ruberg, A.J. VanderWoude, NOAA - GLERL; H. Henderson, CIGLR, University of Michigan, Observing Systems & Advanced Technologies; A. Burtner, University of Michigan, Cooperative Institute for Great Lakes Research (CIGLR). **A Refined Model to Retrieve Dissolved Organic Carbon in the Great Lakes using Ocean Color Remote Sensing Data**.

Remote sensing of dissolved organic carbon (DOC) is of high interest to the Great Lakes community to better understand dynamics of carbon pools within the lakes. Remote sensing algorithms can detect the abundance of DOC through the magnitude of colored dissolved organic matter (CDOM) absorption, although the exact relationship between DOC and CDOM absorption cannot assumed to be constant over gradient of concentrations. Here we explore the relationships between DOC and CDOM absorption to generate a robust DOC remote sensing retrieval algorithm. *In-situ* CDOM absorption and DOC data were collected from Saginaw Bay (n = 151) and the western basin of Lake Erie (n = 406) in 2015-2017. Analysis showed significant logarithmic relationships between CDOM and DOC for both basins modeled separately and for both basins combined. The Saginaw Bay and Lake Erie models were significantly different from each other while there were no differences noted between the combined model and the individual basin models respectively. The new model was implemented into the Colored Producing Agent Algorithm using MODIS and VIIRS data and validated using an independent DOC and CDOM dataset.

M.J. Sayers, R. Shuchman, B. Hart, R. Sawtell, Michigan Technological University, Michigan Tech Research Institute; P.C. Esselman, U.S. Geological Survey. **A New Underwater Hyperspectral Radiometer System for Improved Bottom Albedo Characterization**.

Submerged aquatic vegetation (SAV) is important to the health or freshwater systems as they provide crucial habitat to an array of aquatic organisms. In light of this importance, better understanding of freshwater SAV dynamics is an important step to developing robust ecological management practices. The Michigan Tech Research Institute (MTRI) has developed a underwater hyperspectral radiometer system that integrated onto the USGS Iver3 underwater vehicle. The Iver3 is equipped with a stereo-imaging system to create bottom structure and estimate SAV biomass. Together, these systems will be able to provide a database of bottom albedo and associated SAV parameters which are essential for development of hyperspectral remote sensing algorithms. MTRI tested this system in Lake Michigan in August 2020. Results suggest the system is capable of producing robust estimates of bottom albedo. The very fine scale albedo measurements were compared with near-coincident high/moderate resolution satellitedata to evaluate sub-pixel variability in bottom types. Lastly, we used the bottom albedo and water optical property data to develop a bottom type spectral library.

M.A. Schmidt, Trent University, Trent School of the Environment; C. Eimers, Trent University, School of the Environment. **Nitrate groundwater contamination in Lake Ontario watersheds: data mining informs spatial patterns.**

Nitrate contamination has been established as a pervasive contaminant of agricultural watersheds across the globe. In Ontario, there has been a trend towards greater production of fertilizer-intensive corn and/or N-fixing soybean row crops. There has also been an expansion of tile drainage within agricultural watersheds along Lake Ontario. These factors have been shown to increase non-point source nitrate contamination. This study had two objectives: (1) to examine spatial relationships between groundwater chemistry, surficial geology and landuse/landcover (LULC) datasets within a geographic information system (GIS); (2) to assess the relative contribution of these variables using principal component analysis (PCA). The results of this study can be used to inform the vulnerability of groundwater resources to nitrate contamination.

A. Schmidt, Cooperative Institute for Great Lakes Research, University of Michigan, School for Environment and Sustainability; K. Marko, U.S. Environmental Protection Agency; E. Rutherford, B. Eadie, M. Lansing, NOAA Great Lakes Environmental Research Laboratory; B. Kennedy, University of idaho, Department of Fish and Wildlife Sciences; J. Blum, University of Michigan, Department of Earth & Environmental Sciences; C. Riseng, M. Wiley, University of Michigan, School for Environment and Sustainability; D.M. Mason, NOAA Great Lakes Environmental Research Laboratory. **Characterizing trophic linkages across an estuarine gradient in the Laurentian Great Lakes**.

Tributaries and coastal wetlands provide critical spawning and nursery habitats for key fish species in the Great Lakes. In spring, summer, and fall of 2003, we sampled biota and used carbon (C), nitrogen (N), and strontium (Sr) stable isotopes and stomach analysis to investigate food webs and movements of Chinook salmon, walleye, and alewife across a habitat gradient from Muskegon River to the nearshore zone in SE Lake Michigan. Spatial analysis of C and Sr stable isotope signatures indicated fish habitat dependence varied among Muskegon River segments, Muskegon Lake, and nearshore Lake Michigan. Bayesian stable isotope mixing model results for C and N, when combined with stomach content data, revealed differences in food webs supporting adult and juvenile fish life stages within and among species. Our findings provide a baseline understanding of tributary-lake linkages which can be used to assess further food web changes and inform fisheries management and conservation efforts.

N. Schroeck, University of Detroit Mercy, School of Law; S. Svoboda, Great Lakes Now, Detroit Public TV. **Carp, climate change and Canadian pipelines: A decade of news and law in Great Lakes media**.

For more than a decade, law professor Nick Schroeck and journalist Sandra Svoboda have talked fish, pipelines, ballast water and other Great Lakes issues for her stories, segments and audience engagement efforts. Schroeck, former director of the Great Lakes Environmental Law Center, also has run clinical law programs at Wayne State University and now University of Detroit Mercy. Over the same time, Sandra first worked at an alternative weekly newspaper, then public radio and now public television where she's the program director of the Great Lakes Now initiative. From carp to collaboration, from a printed newspaper to digital video, this pair will review the issues and the platforms, offering tips for how to work with journalists and interview effectively for different types of media.

A.E. Scofield, US Environmental Protection Agency, Great Lakes National Program Office; A.J. Bramburger, Environment and Climate Change Canada, Watershed Hydrology and Ecology Research Division; C.T. Filstrup, University of Minnesota Duluth, Natural Resources Research

Institute; R. MacLellan-Hurd, Oak Ridge Institute for Science and Education, EPA Great Lakes National Program Office; E.D. Reavie, University of Minnesota Duluth, Natural Resources Research Institute; L. Rudstam, J.M. Watkins, Cornell University, Natural Resources. **Vertical structure of phytoplankton in the Great Lakes based on fluoroprobe profiles**.

The use of multi-spectral fluorometers for assessment of phytoplankton has emerged as a popular method to supplement phytoplankton taxonomy datasets. Instruments such as the fluoroprobe allow for the determination of coarse algal divisions at higher spatial, temporal, and depth resolutions than is practical using traditional microscopy techniques. Appropriate use and interpretation of these data requires in-lake calibrations for yellow substances and ground-truthing with microscopy data. Using data generated by the EPA Great Lakes National Program Office long-term monitoring program, we present a brief comparison of fluoroprobe results for the Great Lakes with those from more traditional analyses of chlorophyll-a concentrations and phytoplankton community structure based on microscopy. We then investigate the vertical structure and community composition of deep chlorophyll layers based on fluoroprobe profiles collected over the past decade. When paired with traditional sampling techniques, analysis of fluoroprobe data can provide valuable supplementary information on the structure of phytoplankton communities in large lakes.

K.T. Scribner, Dept. Fisheries and Wildlife, Michigan State; D. Larson, Department of Fisheries and Wildlife, Michigan State University; M. Gass, Michigan State University Extension, Michigan Sea Grant; B. Schroeder, Michigan Sea Grant; E. Baker, Michigan Department of Natural Resources. **Virtual learning to train community scientists about lake sturgeon and coupled Great Lakes-tributary ecosystems**.

Educating K-12 students, STEM educators, and the general public about Great Lakes ecosystems and inter-dependencies between fish communities and physical and biological processes of streams used by migratory fishes will increase awareness of resource stewardship. Using charismatic lake sturgeon and Great Lakes-tributary migratory fishes as a 'hook', we have developed a virtual learning program that uses videography to document movements of lake sturgeon and predatory and prey fishes into and out of the Black River in Michigan during the spawning season. We will describe the online resources including presentations on lake sturgeon ecology, coupled Great Lakes-tributary ecosystems and effects of human disturbance, and community ecology focusing on predator-prey dynamics. Students communicate fish species counts and timing of movements to inform lake sturgeon researchers of changes in fish community composition that likely affect lake sturgeon mortality during early life stages.

F. Seglenieks, A. Temgoua, N. O'Brien, Environment and Climate Change Canada, National Hydrological Services. **Future water levels on the Great Lakes basin based on climate change and stochastic analysis**.

Changes in the future lake levels of the Great Lakes are an important area of study at Environment and Climate Change Canada (ECCC), as these changes will have significant impact on the environment, economy, and overall quality of life on the coastal areas of the region. One method to calculate these future levels is through the use of regional climate models (RCMs) based on CMIP5 scenarios driven by various members of the Coordinated Regional Climate Downscaling Experiment (CORDEX). As well, another method is as part of a larger effort by the Great Lakes Adaptive Management Committee, where a stochastic analysis of 60 000 years of lake levels is also available. This study presents the characteristics of these projected lake levels, i.e., the average mean along with both high and low extremes, and compares the results using both of these methods.

J.P. Selegean, U S Army Corps of Engineers, Detroit District, Great Lakes Hydraulics and Hydrology Office; E. Eisemann, USACE ERDC; E. Lentz, USGS; J. Potthoff, K. McClain, USACE Chicago; F. Fitzpatrick, U.S. Geological Survey; B. Krumwiede, CSS Inc on contract at NOAA Office for Coastal Management, Great Lakes Office; S. McGill, C. Sylvester, USACE ERDC; J. Waddell, USACE Detroit; E. Pendelton, USGS; L. Dunkin, USACE ERDC; W. Barnhardt, USGS; T. Friona, ERDC EL; D. Ager, USEPA Region 5 Great Lakes National Program Office.
Quantifying coastal resilience on Lake Michigan with a nearshore geomorphic vulnerability index.

How quickly a reach of shoreline recedes depends primarily on two factors, 1) the resistance inherent in the bluff, and 2) the amount of wave energy that strikes the bluff. In this paper, we identify the major geomorphic features in the coastal zone that intercept and transform offshore wave energy, thus reducing the energy reaching the bluff. Using airborne lidar data sets we extract coastal profiles every 100 meters along the shore. It is believed that the following features play the most significant role in reducing offshore wave energy from reaching the bluff, 1) nearshore bar characteristics (number of bars, distance offshore and depth of water over the bar), 2) nearshore slope, 3) shape/curvature of the nearshore and 4) beach width. A Bayesian statistics approach will be used to quantify the role that each of these individual features play in created coastal resilience. This information can be used to better understand why some reaches of shoreline erode faster than others and can help guide restoration efforts in choosing the most effective structures to place in the nearshore (engineered bars, beach nourishment activities, et c.).

M. Selzer, Michigan Department of Environment, Great Lakes, & Energy, Water Resources Division; E. Washburn, Washburn Environmental Solutions, LLC; J.F. Bratton, LimnoTech.
Michigan's Active Adaptive Management Approach to Reduce Lake Erie Harmful Algal Blooms.

The state of Michigan has developed a Lake Erie Adaptive Management Plan (AMP) as a companion document to the 2018 Domestic Action Plan (DAP). The AMP describes how the state is moving from "passive" to "active" adaptive management. This presentation will describe: 1) the status of the DAP and final AMP goals, targets, and key metrics; 2) technical underpinnings and internal programmatic enhancements to achieve the 40 percent phosphorus loading reduction goals by 2025; 3) ongoing needs for technical elements to guide decisions; 4) data and information gaps requiring research and additional monitoring to reduce uncertainty in the adaptive management process; 5) the importance of collaboration across jurisdictions; and, 6) the outside expert and stakeholder engagement processes, including development of social indicators, improved transparency, and collaboration in decision-making among groups with an interest in Michigan's portion of the Lake Erie basin.

K. Semmendinger, S. Steinschneider, Cornell University, Department of Biological and Environmental Engineering; L.M. Fry, D.H. Lee, NOAA, Great Lakes Environmental Research Laboratory. **Exploration of the Sensitivity of Lake Ontario Flow Regulation to Annual Water Supply Forecast Skill**.

Water releases from Lake Ontario into the St. Lawrence River are regulated by the International Joint Commission Orders of Approval. The current policy, Plan 2014, is the first regulation plan to use water supply forecasts to guide releases. We explore the sensitivity of the plan to annual water supply forecast skill by conditioning release decisions on the plan's current statistical forecasts, perfect forecasts, and synthetically generated forecasts of varying accuracy. We focus on how these different forecasts can support flood risk reduction upstream (Lake Ontario) and downstream (Montreal, Quebec) of the dam. In most cases, perfect forecasts lead to reductions in flood levels on Lake Ontario without increasing flood levels at Montreal. Further, water level

reductions are possible when forecast accuracy increases by 20-30% over current statistical forecasts. However, improved forecast skill does not lead to better release decisions and flooding outcomes in some instances, and we characterize these types of events.

R.S. Shahmohamadloo, University of Guelph, Department of Integrative Biology; G. Hankins, K. Hubbs, P. Konopelko, M. Sarnacki, D. Strong, A. Vander Eyken, University of Guelph, School of Environmental Sciences; X. Ortiz Almirall, Ministry of the Environment, Conservation and Parks, Toxic Organics Unit; T. Watson-Leung, Ministry of the Environment, Conservation & Parks, Aquatic Toxicology Unit; D.B. Simmons, Ontario Tech University, Faculty of Science; J. Lumsden, University of Guelph, Department of Pathobiology; S. Bhavsar, Ontario Ministry of Environment, Conservation and Parks; P.K. Sibley, University of Guelph, School of Environmental Sciences. **Microcystins, intracellular and extracellular, of cyanobacteria can cause disease-related effects in fish**.

Freshwater fish accumulate microcystins in vital organs; however, differences in the toxicodynamics between exposure to its intracellular and extracellular states (i.e., within and outside cyanobacterial cells) are still poorly known. To address this, Rainbow Trout (*Oncorhynchus mykiss*) at adult and juvenile life stages were exposed for 96 h to both states. Fish were sacrificed at 24-h intervals and dissected to perform histopathology, measure microcystins using targeted LC-QTOF MS, and examine toxic effects using non-targeted proteomics. Fish accumulated microcystins at significantly higher levels in extracellular than intracellular. Biomarkers related to oxidative stress and carcinogenesis significantly increased in all tissues exposed to both microcystin states, with a higher increase when exposed to extracellular microcystins. Histopathology supported these findings with evidence of acute lesions, necrosis, apoptosis, and haemorrhage at similar severity in both microcystin states.

E. Shaw, Michigan Technological Univ., Civil and Environmental Engineering; V. Gagnon, Michigan Tech University, Great Lakes Research Center; E. Ravindran, Keweenaw Bay Indian Community, Natural Resources Department. **Seasons of research with/by/as the Keweenaw Bay Indian Community**.

In response to generations of inequitable research to/for Indigenous communities, many Tribal Nations are developing research practices that center their priorities. In this talk, we share a Seasons of Research framework developed by the Keweenaw Bay Indian Community and University collaborators. The medicine wheel is used to illustrate an interconnected system of partnership teachings. It aims for balance between and among four seasons of research: relationship building, planning and prioritization, knowledge exchange, and synthesis and application. Research partnerships with/by/as the Community demonstrate respect for each other's differences, honor reciprocity in actions, exemplify responsibility for differing commitments, and express reverence for shared lands, waters, and living beings. The co-authors will share examples of and reflections on seasons of research in Lake Superior's Keweenaw Bay, bridging Indigenous wisdom, social and natural sciences, and environmental engineering.

K. Shchapov, T. Ozersky, University of Minnesota-Duluth, Large Lakes Observatory. **Seasonal changes in zooplankton and seston fatty acid profiles in nearshore regions of Lake Superior**.

The ability to store fats and use them during winter is a key survival strategy for many zooplankton species. Given the ongoing effects of climate change on lake winter conditions, improved knowledge of full-year seasonal dynamics and sources of fatty acids (FA) is crucial for understanding lake food webs. Here we provide a whole year study of bulk zooplankton and seston FA concentration and composition at 5 nearshore stations in Lake Superior. We found that total FA concentrations in zooplankton were higher during the winter-spring transition (68.9±25.2 ug/mg

dry weight) than during the summer-fall period (32.6±10 ug/mg dw). On the other hand, seston FAs varied more between stations and did not show a strong seasonal pattern. Through the year, zooplankton had a higher content of essential FAs, while seston contained more nonessential FA groups. Our study suggests a weak relationship between seston and zooplankton FAs throughout the year across all sampled stations.

C. Sheik, University of Minnesota Duluth, Biology and Large Lakes Observatory; K.E. Natwora, University of Minnesota-Duluth; E.E. Alexson, Natural Resources Research Institute, University of Minnesota Duluth; C.T. Filstrup, University of Minnesota Duluth, Natural Resources Research Institute; A.J. Bramburger, Environment and Climate Change Canada, Watershed Hydrology and Ecology Research Division. **Molecular approaches provide insight to past and present Dolichospermum blooms in Lake Superior**.

Cyanobacterial Harmful Algal Blooms (cHABs) are increasing in frequency, duration, and severity in freshwater ecosystems. While the lower Laurentian Great Lakes (Lake Erie and Ontario) are prone to toxin-producing cHABs, Lake Superior has not seen regular cHAB occurrences, likely due to its cold temperature and oligotrophic nature. During a *Dolichospermum* bloom in 2018, opportunistic samples were taken from the off-shore bloom and investigated with shotgun metagenomics. We assembled a near-complete *Dolichospermum* genome that is highly similar to genomes from Lakes Erie and Ontario and to 16S rRNA genes recovered from Lake Superior sediment cores. Our genome, like the lower LGL strains, is typified by its putative ability to produce a suite of secondary metabolites, like anabaenopeptin, but not frequently-measured toxins like microcystin. The presence of identical 16S rRNA genes deep in sediment cores suggests this organism is endemic to the region and may have bloomed in the past. Nonetheless, the increased presence along shorelines of Lake Superior is disconcerting.

N.K. Shrestha, Environment and Climate Change Canada, Boundary Water Issues Unit; F. Seglenieks, Environment and Climate Change Canada, National Hydrological Services; H. Shen, J. Mai, University of Waterloo, Department of Civil and Environmental Engineering. **SWAT-RAVEN coupled model for enhanced streamflow simulation over the Great Lakes region**.

The Great Lakes basin is characterized by the presence of numerous small to large lakes. While larger lakes are obviously considered in hydrological modelling, smaller lakes are often neglected as they are assumed to have negligible impact or their associated properties such as outlet configuration are unavailable. Recently, a lake and river routing product with explicit consideration of smaller lakes has become available from the Great Lakes Runoff Inter-comparison Project which is part of the Integrated Modelling Program for Canada under the Global Water Futures program. The routing product is incorporated in RAVEN allowing it to run in routing-only (RAVENro) mode. We coupled SWAT and RAVENro models, in which total runoff from SWAT is used as input to RAVENro. The coupled model is run for the GL domain at a daily time step. For comparison purpose, a standalone SWAT model (SWATonly) is also set-up using SWAT's inherent routing. Both models are optimized in OSTRICH toolkit using DDS algorithm. Streamflow results at 7 WSC stations in Ottawa river basin showed slightly better performance of the coupled model (KGE = 0.76) compared to the SWATonly model (KGE = 0.72).

R. Shuchman, M.J. Sayers, Michigan Technological University, Michigan Tech Research Institute; T. Moore, Florida Atlantic University, Harbor Branch Oceanographic Institute; G.L. Fahnenstiel, Michigan Tech Research Institute; C. Binding, Environment and Climate Change Canada; J. Lekki, NASA, Glenn Research Center; S. Ruberg, A.J. VanderWoude, NOAA - GLERL. **Development of Adaptive Hyperspectral Algorithms for Improved Chlorophyll and HABs Retrievals from PACE**.

NASA will launch in 2023 a dedicated ocean and freshwater sensing satellite system called Plankton, Aerosol, Cloud, ocean Ecosystem (PACE). A key instrument on PACE is a hyperspectral ocean color imager (OCI). Presently, the majority of algorithms that utilize ocean color satellite data to generate chlorophyll and Harmful Algal Blooms (HABs) concentration retrievals operate on fixed wavelength multispectral bands. The new system on board the PACE satellite will allow for selection of bands every five nanometers from 340 – 890 nm within the visible and near IR spectrum. These numerous bands can be combined dynamically to improve retrieval accuracies. As part of the PACE science team this group of scientists are developing a suite of dynamic adaptive algorithms based on existing approaches as well as new novel semi-analytic bio-optical models. Initial results to date using ship and tower based hyperspectral reflectance data show the expected accuracy improvements when the adaptive techniques are applied.

C. Sibomana, G. Ndayizeye, S. Buhungu, University of Burundi, Biology; D. Nahimana, University of Burundi, Department of Chemistry. **Benthic macroinvertebrates diversity and physicochemical parameters in Lake Tanganyika littoral zone**.

A study on the diversity of benthic macroinvertebrates in relation to physicochemical parameters was carried out in littoral zone of Lake Tanganyika for the contribution to the lake monitoring initiatives for its sustainable management. Tanganyika is the oldest African great lake and one of the richest freshwater ecosystems but is threatened by climate change, water pollution and overfishing. Bujumbura is the biggest and most populated city around the lake and Benthic macroinvertebrates and physicochemical parameters were sampled at two sites, one at Bujumbura shore and the other near south of the city. Only dissolved oxygen, phosphates, COD and transparency showed significant differences while macroinvertebrates families used as pollution indicators show similar patterns. Sites that were considered unpolluted may be undergoing pressure due to agricultural intensification and deforestation and the littoral water in Bujumbura may have been altered by the raising of this lake water level.

J. Simoes, International Institute for Sustainable Development, Water; G. Gunn, IISD Experimental Lakes Area; J. Vanrobaeys, Agriculture and Agri-Food Canada. **Targeting watershed BMPs with PTMApp on the Eastern Prairies**.

The eutrophication of Lake Winnipeg is one of the largest landscape management challenges in western Canada. To address this challenge without compromising Canada's agricultural competitiveness, investments in nutrient stewardship must be targeted to projects that deliver the most value for money on both point sources and non-point sources. Until recently, significant data limitations inhibited modelling and planning of this type on the Canadian Prairies. This project is part of the AAFC Living Labs – Eastern Prairies which includes BMP performance costing, implementation and monitoring and allows us to integrate recent and relevant data to scientists, planners and managers. By leveraging the Living Laboratories approach of co-development and collaboration, we are integrating local farm characteristics, hydrologic modelling and BMP performance data to reduce nutrient runoff and improve lake health.

J.S. Sinclair, Aquatic Ecology Lab, The Ohio State University, EEOB; M.E. Fraker, University of Michigan, Cooperative Institute for Great Lakes Research (CIGLR); J.M. Hood, Aquatic Ecology Lab, The Ohio State University; K.T. Frank, Queen's University; M.R. DuFour, A. Gorman, Ohio Department of Natural Resources, Division of Wildlife; S.A. Ludsin, Aquatic Ecology Lab, The Ohio State University. **Functional traits reveal the dominant anthropogenic drivers of change in Lake Erie fish assemblages**.

Freshwater ecosystems worldwide are being influenced by multiple anthropogenic stressors, yet a full understanding of how to delineate independent stressor effects is lacking. In this

presentation, I discuss how we used long-term (1969–2018) data on the trait composition of fishes in Lake Erie's western and central basins to disentangle interactions among nutrient, temperature, and invasive species stressors. Our results showed that during the 1970s through 1990s both basins exhibited dramatic trait shifts from warmer-water, lower consumers to colder-water, higher consumers. These trait shifts were then reversed in the 2000s and 2010s. Temporal shifts in feeding and related thermal traits primarily matched changes in the effects of altered nutrient inputs and invasive round goby through time. Our findings show the utility of trait-based approaches for resolving multiple stressor interactions and yielding new insights into the community effects of human-induced environmental change.

D.J. Smith, University of Michigan, Earth and Environmental Sciences; J.Y. Tan, University of Michigan, Chemical Engineering; M.A. Powers, University of Michigan, Earth & Environmental Sciences; X.N. Lin, University of Michigan, Chemical Engineering; T.W. Davis, Bowling Green State University, Biological Sciences; G.J. Dick, University of Michigan, Earth and Environmental Sciences. **Individual Microcystis colonies harbor bacterial communities that differ by Microcystis oligotype and with time**.

Microbial interactions in the phycosphere have impacts at the scale of whole ecosystems, including the development of harmful algal blooms. The cyanobacterium Microcystis causes toxic blooms globally, and grows in colonies that harbor other bacteria. Yet the phycosphere communities and the nature of their interactions with Microcystis are not well characterized. To identify the compositional variance within Microcystis phycosphere communities, we performed 16S rRNA amplicon sequencing on individual Microcystis colonies collected biweekly via droplet encapsulation during a western Lake Erie cyanobacterial bloom. The colony communities were distinct from communities in whole water and bulk phytoplankton seston in western Lake Erie, but no taxa were found in all colonies. Colony community similar was correlated with the same sampling date and the Microcystis 16S oligotype. This suggests that bacterial communities associated with Microcystis change with time and with Microcystis genotype.

Z. Song, University of Windsor, Great Lakes Institute for Environmental Research (GLIER); K. Chomicki, Toronto and Region Conservation Authority (TRCA); K.G. Drouillard, University of Windsor, Great Lakes Institute for Environmental Research; P. Weidman, University of Windsor, Great Lakes Institute for Environmental Research (GLIER). **Testing the impacts of multiple factors on nearshore surface water quality in large lakes**.

We studied nearshore water quality of Lake Ontario, near Pickering and Ajax, to investigate how surface water quality in large lakes is influenced by physical, hydrodynamic and climate factors, including geographic proximity to shoreline nonpoint sources and the outfall of Duffin Creek Water Pollution Control Plant, discharges and loadings of nutrients, ions and suspended solids from tributaries and the plant outfall, horizontal water-mixing and climate factors (i.e., air temperature, precipitation, snow cover, ice coverage and duration). Trend surface analysis showed that most water quality parameters decreased in magnitude from shoreline to offshore. Linear mixed model with orthogonal transformation by principal component analysis (LMM) suggested that, while relative importance of these drivers differed among water quality parameters, most parameters were influenced by a combination of multiple physical, hydrodynamic and climate factors rather than a single dominant mechanism. Our study showed how LMM can be used to disentangle the relative importance of divers of nearshore water quality and pollution in large lakes.

S.L. Speir, University of Notre Dame; J.L. Tank, University of Notre Dame, Department of Biological Sciences; M.T. Trentman, U.H. Mahl, University of Notre Dame; L.R. Sethna, T.V.

Royer, Indiana University. **Winter cover crops reduce nutrient losses from fields to waterways in two agricultural watersheds**.

Despite efforts to reduce nitrogen (N) and phosphorus (P) runoff from agricultural landscapes, environmental impacts on freshwater ecosystems persist due to inputs of excess fertilizer nutrients and their legacy on the landscape. For four water years (2016-2019), we quantified reductions in dissolved N and P losses from cropland in response to the widespread planting of cover crops (CC) in two agricultural watersheds (Indiana, USA). We collected water samples bi-monthly from tile drains and stream sites to quantify the effect of CC on nitrate-N and soluble reactive P (SRP) losses from fields to the stream. Cover crops consistently reduced instantaneous tile drain nitrate-N loss (in mg/s) by 52-82% compared to tiles without CC. For SRP, decreases ranged from 49-83% in CC tile drains. Watershed yields (in kg/ha) were driven by runoff, and reductions in spring nitrate-N loss ranged from 17-65%, while spring SRP export was 32-86% lower compared to pre-CC years. Cover crops retain nutrients on fields and reduce N and P losses to waterways, which may be useful in buffering the impacts of increased storm frequency and intensity predicted under future climate scenarios.

D.J. Spiering, New York State Office of Parks, Recreation and Historic Preservation, Ocean and Great Lakes; M. Janis, A. Heminway, L. Bogan, New York State Office of Parks, Recreation and Historic Preservation. **Lessons learned from the East River Marsh restoration in the Niagara River, Grand Island, NY**.

New York State Office of Parks, Recreation and Historic Preservation has been working to restore wildlife habitat within State Parks along the Niagara River Area of Concern (AOC). Two projects to restore coastal wetland habitat occurred at the East River Marsh in Beaver Island State Park, Grand Island, NY. Offshore rock reefs were constructed in 2003 to attenuate wave energy caused by wind and boat wake. The project was successful at expanding coastal wetland behind the rock reefs, however invasive species colonized the rock reefs. Additional rock reefs, as well as other restoration measures were completed in 2018 at East River Marsh adjacent to the 2003 project. Modifications were made to the rock reefs based on observations from the older reefs and new restoration methods were incorporated into the 2018 restoration project. We will discuss lessons learned from these two projects and how they are being applied to other habitat restoration projects within the Niagara River.

J. Stinson, York University, Faculty of Education; N. Akiwenzie, V. Serda, Bagida'waad Alliance; R. Cohen, York University, Faculty of Education. **New Journey to Save Fish: Oshki Maadaadiziwin Jaa Bimaaji'ut Gigooyike**.

In response to observations of climate change impacting weather patterns and populations of lake whitefish on Lake Huron and Georgian Bay, fishing families of the Saugeen Ojibway Nation founded the Bagida'waad Alliance as a registered not-for-profit corporation in 2018. The goals of the organization are to research and educate how climate change is affecting the waters and environment of Lake Huron and Georgian Bay, encourage their youth to document the stories of the Elders, and to promote more active stewardship of the lands and waters. This presentation will describe the results of the project *New Journey to Save Fish: Oshki Maadaadiziwin Jaa Bimaaji'ut Gigooyike,* whichis a partnership between the Bagida'waad Alliance and York University aiming to promote a decolonized and participatory approach to climate change research, education, and outreach, through the medium of documentary film. The project aims to facilitate youth dialogue with Elders about community experiences and responses to climate change, and to mobilize and share this knowledge with a range of audiences through the production of short documentary films.

W. Stott, Michigan State Unviersity CESU; D.B. Bunnell, USGS Great Lakes Science Center, Great Lakes Science Center; K. Donner, Little Traverse Bay Bands of Odawa Indians; C. Olds, U.S. Fish and Wildlife Service, Alpena Fish and Wildlife Conservation Office; J. Smith, Sault Ste Marie Tribe of Chippewa Indians; T. Treska, US Fish and Wildlife Service. **Genetic species identification of coregonines from lakes Michigan and Huron**.

Microsatellite DNA loci were used to classify larval coregonines collected from lakes Michigan and Huron captured between May and July using beach seining and larval tows. Analysis of reference collections of ciscoes (*Coregonus artedi*), bloater (*C. hoyi*), and lake whitefish (*C. clupeaformis*) and hybrids between cisco and lake whitefish and cisco and bloater showed that microsatellite DNA loci could be used to determine the species of larval samples accurately. Lake whitefish were observed most frequently in most years, followed by cisco, and bloater. Lake whitefish and cisco were most abundant in early spring and summer while bloater were sampled more often later in the year. In Lake Michigan, lake whitefish were most often observed at sites located in the main basin while cisco were most common in Grand Traverse Bay and similar numbers of bloater and cisco were captured in Green Bay. In Lake Huron, bloater were most common at all sites sampled.

R. Sturtevant, Michigan State University, Michigan Sea Grant; E.K. Lower, Michigan Sea Grant; A. Bartos, University of Michigan, Michigan Sea Grant; A.K. Elgin, NOAA Great Lakes Environmental Research Laboratory, Lake Michigan Field Station. **History of introduction and competitive impacts of nonindigenous aquatic plants of the Laurentian Great Lakes**.

The Great Lakes Aquatic Nonindigenous Information System (GLANSIS) contains data and information on nonindigenous species in the Great Lakes region, including distribution, risk assessment, and species profile information. We reviewed history and potential competitive impacts of 55 aquatic nonindigenous plant species that may compete with natives. Forty aquatic plant species were introduced prior to 1920, but only 15 were introduced since, with a peak introduction rate occurring in the early 1880s. 55% of these species were deliberately introduced. We found evidence of 46 specific natives - including many at-risk species - experiencing direct competition from 22 specific nonindigenous plant species. Five species (Lythrum salicaria, Typha angustifolia, Iris pseudacorus, Frangula alnus, and Phragmites australis australis) were found to have significant adverse competitive impacts, and 19 others to have resulted in some noticeable stress to or decline of at least one native plant population. Significant questions remain about potential competitive effects of nonindigenous aquatic plants on Great Lakes native plant communities.

S. Svoboda, Great Lakes Now, Detroit Public TV. **Watch This: Using Facebook watch parties to engage new audiences**.

When the world went virtual, so did Great Lakes Now. Beginning in July 2020, the team started doing live watch parties - guests log into a virtual platform, the television engineers produce it to Facebook, and the audience can ask questions through the Facebook chat. From a cockroach cage to a lab in Winnipeg, Manitoba, from aquariums in Detroit and Chicago to home offices across the region, these Facebook Watch Parties have offered dozens of organizations opportunities for audience engagement and media partnerships. GLN Program Director Sandra Svoboda will show some of the highlights (and some bloopers) and give an outline of how your organization can replicate these successful events.

Z. Swan, University of Toledo, Lake Erie Center; T. Bridgeman, University of Toledo, Lake Erie Center & Dept. of Environmental Sci. **Hypoxia in Lake Erie: Temperature's Effect on Phosphorus Release from Anoxic Sediments**.

Harmful Algal Blooms (HABs) have become an annual occurrence in the western basin of Lake Erie (WBLE), jeopardizing drinking water. Annual HAB size is known to be correlated with

external loading of phosphorus (P), while internal loading of P from WBLE lake sediments is calculated to be less influential under aerobic conditions. Under hypoxic conditions, however, P release from WBLE increases, with a large increase at elevated temperatures (30?). The two objectives of this study were to determine the rate of P release from anoxic sediments at temperatures between 20? and 30? in laboratory incubations and secondly, to characterize in situ hypoxic events in the WBLE. Sediment cores were collected from two sites within the WBLE and incubated at 20?C, 23?C, 26?C, and 29?C. Incubation results from one site (7M) showed a large increase in P flux between 23? and 26?, while another site (4P) showed largest increase in P flux between 26? and 29? Water quality instruments were deployed in the WBLE for in situ measurements, which documented a hypoxic event in July 2020, leading to a predicted hypolimnion P increase.

T

A. Taabu-Munyaho, Lake Victoria Fisheries Organization; C. Nyamweya, KENYA MARINE AND FISHERIES RESEARCH INSTITUTE, Limnology; V. Natugonza, Busitema University, Maritime Institute, Namasagali, Uganda; R. Mangeni Sande, National Fisheries Resources Research Institute, Stock Assessment; H. Nakiyende, National Fisheries Resources Research Institute, Uganda, Capture Fisheries and Biodiversity Conservation; E. Mlaponi, Tanzania Fisheries Research Institute, Mwanza; R.J. Kayanda, Lake Victoria Fisheries Organization. **Rapid recovery of fish stocks in Lake Victoria, East Africa, depicts importance of good management**.

Fisheries on the African Great Lakes are largely open access and overexploited. We present a case where strong enforcement on Lake Victoria, in Lates niloticus), the commercially most important species, had increased by 30%. The United Republic of Tanzania adopted a similar approach in 2018, and by 2020, the total biomass in the lake had increased by 63% (2.12 million MT to 3.47 million MT). The largest increase was observed in the Ugandan and Tanzanian waters, with no noticeable change in stock size in the Kenyan waters, where no similar enforcement measures have been implemented. These results demonstrate that effective management measures have impact on fish stock abundance and size structure. Partner States should embrace participatory enforcement for fisheries sustainability.

G.K. Tarsa, H.A. Bootsma, University of Wisconsin-Milwaukee, School of Freshwater Sciences. **Round goby productivity on a rocky nearshore reef in Lake Michigan**.

Since they invaded the Great Lakes region, round gobies (Neogobius melanostomus) have created an energetic linkage between benthic invertebrates and higher trophic levels. As round gobies have become a substantial diet component of many piscivores, a quantitative understanding of round goby productivity is needed to support Lake Michigan fisheries management and invasive species removal projects. To estimate round goby productivity in the rocky nearshore zone of Lake Michigan, we measured round goby density, growth rate, and diet composition on a nearshore reef during June – October 2020, and applied these measurements in a round goby bioenergetics model. Comparisons of round goby biomass and productivity with that of other benthic food web components suggests efficient trophic transfer. Hence round gobies appear to be an important conduit for the transfer of nearshore benthic energy to higher trophic levels, mitigating the negative effects of mussel grazing within the nearshore zone.

K.M. TePas, Illinois-Indiana Sea Grant; E.K. Hinchey Malloy, U.S. EPA, Great Lakes National Program Office; E.A. Whitmore, Cornell University Bio Field Station, Dept. of Natural Resources

and the Environment; N. Singleton, U.S. EPA, Great Lakes National Program Office. **Bring-a-Teacher-to-Work Week**.

Sea Grant's Center for Great Lakes Literacy has a partnership with the EPA to provide a unique learning experience for educators aboard their research vessel, the R/V *Lake Guardian*. The annual Shipboard Science Workshop brings together educators with scientist to work side-by-side for the week, collecting and working up samples, all the while learning about the Great Lakes. This experience provides an opportunity for scientists to further their research while enhancing the educators' capabilities in science. Sometimes the educators integrate the research into their educational programming the following school year, thereby expanding the reach of the research. At times, the opportunity has led to further collaborations between scientists and educators of their own volition. Come hear about the value of this experience for both educators and scientists alike.

E. Theuerkauf, Michigan State University, Dept, of Geography, Environment, and Spatial Sci.; L. Zoet, University of Wisconsin-Madison; C. Mattheus, University of Illinois at Urbana-Champaign; E. Bunting, Michigan State University; J. Rawling, University of Wisconsin-Madison. **Nearshore response to coastal Great Lakes storms: insight from recent studies using drones and ROVs**.

During periods of high Great Lakes water levels, it is well documented that rates of coastal erosion increase as the zone of wave influence translates landward. Similarly, the protective barrier of shore ice is removed during times of low winter ice cover, thus enhancing erosion during winter storms. In both scenarios, shoreface morphodynamic processes and sediment transport pathways are poorly constrained with field data, creating a challenge for predicting future coastal response. With the development of time and cost-efficient remote sensing methods such as drones and ROVs we are now able to quickly capture the dynamics of these coastal processes. This talk will discuss findings from recent studies conducted by our group that have employed these technologies along the shores of Lakes Michigan and Superior to better understand: 1) beach and dune response to winter storms with no winter shore ice present, 2) beach and nearshore response during periods of variable and persistent winter shore ice, 3) beach and nearshore response to fall storms, and 4) the feasibility of incorporating citizen scientists into drone-based coastal storm monitoring.

M. Thiess, Parks Canada, Ontario and Waterways; C. Masson, Trent University, School for the Study of Canada. **Introduction: Canada's post-2020 global to local freshwater biodiversity goals and targets**.

Canada’s Great Lakes and inland waters hold one fifth of global freshwaters with over two million lakes and 8,500 rivers covering 9 percent of total surface area, including 24 percent of global wetlands, the world’s longest coastline, second-largest land mass, 25 percent of temperate rainforests and 33 percent of boreal forest. In September 2020,Canadajoined the High Ambition Coalition of countries advocating for the conservation of 30 percent of the world’s lands and oceans by 2030 during upcoming post-2020 Global Biodiversity Framework consultations at the 15th Meeting of the Conference of the Parties to the Convention on Biological Diversity. How we share, protect, conserve and restore life-sustaining ecosystems and resources will define us for generations to come. During this session, an expert panel will address global-to-local biodiversity goals and targets, focusing onCanada’s commitments and achievements. The aim is to foster multilevel, crosscutting discussions and actions.

M. Thiess, Parks Canada, Ontario and Waterways. **Opening in a Good Way: Land Acknowledgement and Welcome**.

Elder and Knowledge Keeper Dorothy Taylor is from Curve Lake First Nation and is a member and founder of the Mississauga Sacred Water Circle. She routinely teaches to our youth that all Our Relatives can help us all with the pressures of the climate crisis. She likes to explain

Indigenous spiritually for those who will listen, and what it means for those of us concerned with the fate of the planet. In the past, Dorothy was also responsible for youth involvement and job placement through her role as economic development for Curve Lake First Nation. It was often said around the community, if a youth got a job or passion for the protection of Mother Earth, then Dorothy was not far behind.

M. Thiess, Parks Canada, Ontario and Waterways. **United Nations Convention on Biological Diversity and the 2021 Global Biodiversity Framework**.

Advances toward implementation of the United Nations 2030 Agenda for Sustainable Development will enable the landmark 2021 Global Biodiversity Framework (GBF), scheduled for adoption by the 196 Parties to the Convention on Biological Diversity (CBD) at the October 2021 UN Biodiversity Conference (CBD COP15). The CBD addresses biodiversity, ecosystem and climate change threats through science assessments, tools, incentives, technology transfer, good practices and the active engagement of major groups such as indigenous and local communities, youth, NGOs, women and business. The GBF will replace the 2011-2020 Aichi Targets that did not accelerate progress to the extent required, although certain components were met. Transformative actions towards the 2050 Vision for Biodiversity, 'Living in Harmony with Nature,' require governments and international institutions to establish enabling environments through financial investments and by integrating scientific knowledge into policy solutions.

M. Thiess, Parks Canada, Ontario and Waterways. **Science, Law, Policy and Culture for Freshwater Biodiversity Protection: A Guided Discussion**.

The conservation of biological diversity, sustainable use, and the fair and equitable sharing of genetic resources are contingent upon co-management, where respect for Indigenous peoples' knowledge and practices are enshrined in legislation, and integrated into global to local biodiversity commitments; toward the primary outcome of reconciliation with the Earth. Indigenous place making uses community strengths to create Indigenous presence in public spaces reflecting community identity, health and well-being. The 2018 Pathway to Canada Target One initiative: 'We Rise Together: Report of the Indigenous Circle of Experts' (ICE 2018), focused on Ethical Space as a refuge of possibility, or bounded partnership model where settler and indigenous researchers collaborate and share knowledge. QUESTIONS 1) What do you see as barriers/opportunities to creating Ethical Space, and adopting Indigenous place making? 2) How might Ethical Space partnerships contribute to ecological restoration?

M. Thiess, Parks Canada, Ontario and Waterways. **Closing in a Good Way: Summary and Next Steps**.

2021 is a very active year of high-level environmental negotiations toward the Global Biodiversity Framework. Canada is party to key declarations, treaties, legislation, conventions and agreements toward protecting 25% of global lands, oceans and inland waters by 2025 – and 30% by 2030. The official launch of the United Nations Decade on Ecosystem Restoration 2021–2030 is on World Environment Day, June 5, 2021. Local to global assessments are an important mechanism for information synthesis and effective decision making at multiple levels of scale.

D. Titze, D. Beletsky, University of Michigan, Cooperative Institute for Great Lakes Research; J. Kessler, L. Mason, E.J. Anderson, L.M. Fry, NOAA, Great Lakes Environmental Research Laboratory; L. Read, National Center for Atmospheric Research; W. Saunders, NOAA, National Weather Service Northeast River Forecast Center; P. Chu, J.C. Feyen, D.H. Lee, NOAA, Great Lakes Environmental Research Laboratory. **Development of a Flood Forecasting System for Lake Champlain**.

In 2016, the International Joint Commission began a $14M, 5-Year study to explore solutions to flooding in the binational Lake Champlain-Richelieu River system. The study was prompted by the record flood of 2011, which caused destruction of property and infrastructure in the binational basin. Flooding can occur in the spring as a result of rapid snowmelt and intense rain, and can be enhanced by storm surges and wind waves that build over the long north-south fetch of the lake. To better predict flood events, a flood forecasting system is being developed for the Lake Champlain-Richelieu River basin. The system will resolve wind-driven spatial variability in water levels, surface waves, and the associated extent of coastal inundation, thus improving upon an existing one-dimensional model that is currently used for forecasting. Hindcast results show strong agreement with water level observations. An experimental real-time application of the forecasting system began operation in 2020.

A. Trebitz, U.S. EPA, Office of Research and Development; J.C. Hoffman, US EPA, Great Lakes Toxicology and Ecology Division; G. Peterson, US EPA Office of Research and Development; C. Hatzenbuhler, SpecPro Proffesional Services; J. Barge, A. Szczepanski, Oak Ridge Associated Universities. **Nearshore Lake Superior invertebrate biodiversity patterns from two high-density surveys**.

Despite recognition that invertebrate fauna in nearshore regions of the Great Lakes can differ substantially from offshore regions, datasets amenable to exploring nearshore biodiversity patterns remain limited. Here, we use two spatially intensive Lake Superior nearshore invertebrate surveys to explore taxa prevalence patterns, differences from offshore communities, non-native taxa occurrence, spatial covariance, and environmental factors. Data come from ~290 benthos samples from the Bayfield Peninsula coastline (year 2013) and ~100 zooplankton and ~150 benthos samples from the Apostle Islands (year 2017) that collectively contain 25+ crustacean zooplankton taxa and ~400 benthos taxa. Over 30% of zooplankton and 60% of benthos taxa were numerically rare (at 2% of stations) and several appeared on state rare-species lists. Besides Bythotrephes, non-native species came primarily from benthic oligochaetes, amphipods, and mollusks. Within the 30m depth cutoff typically used to define 'nearshore', we found considerable variability in community composition related to depth, exposure, and substrate.

T.R. Tucker, U.S. Geological Survey, Great Lakes Science Center; S. Tank, P. Canniff, Great Lakes Commission; C.E. Dumoulin, University of Georgia, Georgia Cooperative Fish and Wildlife Research Unit, Warnell School of Forestry and Natural Resources; C.T. Bargeron, University of Georgia, Center for Invasive Species and Ecosystem Health; E. Jensen, Great Lakes Commission; C.T. Moore, U.S. Geological Survey, Georgia Cooperative Fish and Wildlife Research Unit Assistant Unit; K.P. Kowalski, U.S. Geological Survey, Great Lakes Science Center. **The Phragmites Adaptive Management Framework: Programmatic quality control of participatory data**.

The success of participatory science programs relies on a program structure that promotes collection of high-quality data while simultaneously making data collection accessible to participants of varying experience levels. The *Phragmites* Adaptive Management Framework (PAMF) is a collective learning program that utilizes adaptive management to reduce uncertainty in the management of non-native *Phragmites australis* throughout the Great Lakes basin. PAMF participants collect *Phragmites*monitoring and management data on a yearly basis to inform the PAMF predictive model, which in turn provides all participants with data-driven, site-specific management guidance for the next year. Promoting quality assurance early in the adaptive management cycle is key to model learning and production of reliable management guidance. We highlight the PAMF approach to ensuring data quality on the front-end through the program's design, including the development of standardized data collection protocols and an online data entry portal. Regular engagement with participants via online and in-person training also promotes the collection of high-quality data.

J.T. Ives, University of Windsor, Great Lakes Institute for Environmental Research; L. Tunu Kaaya, African Center for Aquatic Research and Education. **Building leadership for early-career African women scientists in the African Great Lakes region**.

African women comprise only 30% of sub-Saharan researchers in all subject areas and are often concentrated in the lower levels of responsibility and decision-making with limited leadership opportunities. With an understanding that science benefits from gender equality women scientists as leaders, the African Center for Aquatic Research and Education's (ACARE) has launched a 2021 program for early-career African women scientists from the African Great Lakes region. Participants are a cohort of women from multiple countries bordering the African Great Lakes who are engaged in research on the lakes and/or their tributaries. Program objectives are to build the capacity, skills and networks of participants through mentoring and workshops. At this session, we'll share the program design, participant feedback and nascent outcomes.

M.T. Tuttle-Lau, USFWS, Fish and Aquatic Conservation. **Process Improvements to a long-term eDNA Monitoring Program**.

Adaptive Management itself is an action taken for continual improvement throughout a project lifecycle. The connection between Quality Assurance and Adaptive Management is in the iterative learning process, and produces improved understanding and improved management over time. The USFWS Region 3 Fisheries and Aquatic Conservation Program has led high throughput eDNA monitoring activities for invasive Bighead and Silver Carp in the Great Lakes and Mississippi River basins since 2013. Since FWS implementation, staff within the program have identified areas for improvement, including moving to digital data collection and various process refinements for how a carp detection is made. These improvements have strengthened our data quality, data management and our confidence in our decision-making ability. In tandem with other Quality Assurance initiatives, these process improvements are part of a larger scope of a programs Quality System. This presentation will outline the steps that staff have taken to make process improvements, which have led to improvements in data quality, data management and overall confidence in the Region 3 eDNA program.

M.R. Twiss, Clarkson University, Department of Biology; L.B. Johnson, University of Minnesota Duluth, Natural Resources Research Institute; M. Child, International Joint Commission; L. Wang, International Joint Commission, Great Lakes Office. **Operationalizing a Great Lakes Early Warning System: Progress by the IJC Science Advisory Board**.

The IJC's Science Advisory Board is developing a Great Lakes Early Warning System (GLEWS) to alert the Boundary Waters Treaty signatories (Canada, United States) to emerging stressors and threats. In 2019, the Board completed the first phase of GLEWS, which includes a recommended organizational approach. The second phase of the project was initiated in late 2020. The second phase will develop a generalized analytical protocol and decision framework, identify data sources, indicators, benchmarks and thresholds for different classes of threats (chemicals, nutrients, climate change, biological and human & behavioral), and test the analytical protocol and decision framework through a case study approach. This presentation will summarize progress to date. Insights gained through this presentation and other presentations in this session will inform a planned IJC Science Advisory Board workshop, and enhance recommendations for operationalizing the Great Lakes Early Warning System.

C. Tyler, Rochester Institute of Technology, Thomas H. Gosnell School of Life Sciences; M. Chado, Rochester Institute of Technology; J.M. Daily, Rochester Institute of Technology, School of Mathematical Sciences; R. Diaz, K.M. Chomiak, C.M. Bangkong, Rochester Institute of Technology, Thomas H. Gosnell School of Life Sciences; N. Eddingsaas, Rochester Institute of Technology,

School of Chemistry and Materials Science; A. Hudson, Rochester Institute of Technology, Thomas H. Gosnell School of Life Sciences; O. Martin, N. Schneider, Rochester Institute of Technology; M.J. Hoffman, Rochester Institute of Technology, School of Mathematical Sciences; S.W. Day, Rochester Institute of Technology, Kate Gleason College of Engineering. **Microplastic deposition potential in freshwater ecosystems of the Lake Ontario basin**.

Hydrodynamic models and empirical studies suggest that a significant fraction of microplastics entering freshwater ecosystems is deposited in the sediments. However, much uncertainty remains about transport pathways. Biofouling and changes in chemical and physical properties may vary by polymer type and characteristics of the receiving water body, driving the rate of particle sinking. We incubated six post-consumer plastics at the surface and benthos of four ecosystems in the Lake Ontario watershed: Conesus Lake, rural pond, stormwater retention pond, and nearshore Lake Ontario. Particles were harvested after one and four months, and assessed for changes in surface properties and settling potential relative to pristine materials. Variation in settling velocity across time, ecosystems, and polymer types was observed. These results suggest that the risk to the benthos varies depending the transport pathway, with divergent implications for benthic organisms and ecosystem function.

E. Tyner, University of Wisconsin-Green Bay, Cofrin Library, CL815-D; B. Faust-Accola, NOAA, Office for Coastal Management. **Establishing a National Estuarine Research Reserve for the Lake Michigan-Huron Biogeographic Region**.

In recognition of the ecological, cultural, and historical importance of estuarine and wetland areas within the Lake Michigan-Huron basin, the University of Wisconsin-Green Bay is leading the process of designating a National Estuarine Research Reserve (NERR) within the waters of Green Bay. If designated, the Green Bay NERR would be the third NERR within the Great Lakes. The NERR System is a national network of 29 sites designed to protect and study estuaries. A Green Bay NERR would offer a coordinating force to restore and protect estuarine areas, with a programmatic focus on research, education, stewardship, and training. A NERR designation consists of six formal steps, of which we are currently in Step Two, the evaluation of potential sites. This stage includes broad public outreach; establishing site-selection criteria; the identification of 3-5 top candidate sites; and the nomination of a final site. We will discuss the history of designating a reserve in the waters of Green Bay, the benefits of the reserve system, and opportunities for the IAGLR community to share their vision for a new Great Lakes National Estuarine Research Reserve.

U

D.W. Ure, S. Hassanzadehroknabadi, University of Windsor, Department of Chemistry and Biochemistry; J. Rodgers, Z. Rodgers, Bruce Peninsula Biosphere Association; C. Lalonde, C. Little, Lower Thames Conservation Authority; R. Carlow, D. Bittman, Lower Thames Valley Conservation Authority; B. Mutus, University of Windsor, Department of Chemistry and Biochemistry.
Multimetal Hydrogel Composites for the Removal of Inorganic Phosphate from Tile Drainage.

The removal of nutrients such as phosphate and nitrate by filtration at tile drainage sites is one method to mitigate eutrophication. An inexpensive hydrogel composed of iron and carboxymethyl cellulose (CMC-Fe) has high binding capacity (~20 mg/g) and affinity ($K_{D\,App}$ = 24.81 μM). Under laboratory conditions, CMC-Fe was capable of removing ~94.5 % of phosphate. A prototype manufacturing system for producing large scale (600-1000 kg) of CMC-Fe was designed and implemented. The results of a field test at a tile drainage site in Chatham-Kent, Ontario will be presented. We have also undertaken, a systematic approach to improve on the P-binding capacity,

affinity, and selectivity of the hydrogel-metal composites. These new studies have yielded a bimetallic composite of aluminum and iron, with a P-binding capacity of ~50 mg/g. The retained P-binding capacity in the presence of 10:1 chloride, nitrate, or sulfate is 88.1 %, 88.3 %, and 77.7 % respectively.

V

A. Vazquez-Ortega, Bowling Green State University, School of Earth, Environment and Society; M.J. Franks, Bowling Green State University; E. Duncan, Los Angeles Regional Water Quality Control Board; K. King, United States Department of Agriculture. **Role of Fe- and Mn-(oxy)hydroxides on Carbon and Nutrient Dynamics in Agricultural Soils**.

Fe- and Mn-(oxy)hydroxide minerals play a key role in soil organic carbon (SOC) stabilization and sequestration, as well as nutrient adsorption. To better understand the mineral phases responsible for the stabilization and sequestration of SOC, as well as PO_4^{-3} and NO_3^-; a chemical sequential extraction was applied to agricultural soils under different tillage management practices. Results showed that SOC was stabilized in the following order: crystalline Fe-(oxy)hydroxide > amorphous Fe-(oxy)hydroxide > Mn-(oxy)hydroxide. Fe- and Mn-(oxy)hydroxide minerals adsorbed PO_4^{-3} species to a large extent; however, NO_3^- was adsorbed marginally. Results indicated that PO_4^{-3} adsorption is largely mediated by Fe- and Mn-(oxy)hydroxide minerals, and NO_3^- by bulk soil organic matter. Understanding the coupling interaction between SOC, nutrients, and mineral phases in agricultural soils can better inform the adoption of best management practices to minimize the nutrient export into waterways.

C. Vandergoot, Michigan State University, Fisheries and Wildlife; M. Faust, Ohio Department of Natural Resources, Division of Wildlife. **Knowledge gaps in Great Lakes fish movement studies: what have we learned over the past decade?**

The ability of fishery decision makers to understand the movements and spatial ecology of fish populations is integral to manage exploited fishes, conservation and restoration of native fishes, and invasive species management. Landsman et al. (2011) identified seven movement-related knowledge gaps associated with Great Lakes fish populations after reviewing the literature and conducting interviews with fishery managers across the basin. Specifically, the authors identified a lack of information related to: 1) inter-lake fish movement patterns, 2) dispersal of stock fish from original stocking locations, 3) movements of invasive species, 4) forage fishes, 5) recovering fish population, 6) predator-prey interactions, and 7) the effect of barriers on tributary fish movements. Here, we evaluate progress toward addressing these knowledge gaps after a decade of acoustic telemetry studies conducted throughout the Laurentian Great Lakes and identify where knowledge gaps still exist.

H.A. Vanderploeg, NOAA GLERL; C.M. Godwin, University of Michigan, Cooperative Institute for Great Lakes Research; A.K. Elgin, NOAA Great Lakes Environmental Research Laboratory, Lake Michigan Field Station; T.H. Johengen, University of Michigan, Cooperative Institute for Great Lakes Research (CIGLR); V.J. Denef, University of Michigan, Ecology and Evolutionary Biology; H.J. Carrick, Central Michigan University, Biology & Institute for Great Lakes Research; P. Glyshaw, NOAA Great Lakes Environmental Research Laboratory; G. Carter, Cooperative Institute for Great Lakes Research; A. Burtner, University of Michigan, Cooperative Institute for Great Lakes Research (CIGLR); A. Camilleri, Cooperative Institute for Great Lakes Research, University of Michigan. **Dreissena feeding and nutrient excretion affects seasonal succession of plankton in Lake Erie**.

We measured feeding and nutrient excretion of quagga mussels April – October in water collected from western Lake Erie. Several measurement approaches (size-fractioned chlorophyll, FluoroProbe, FlowCAM, 'omics) showed that quagga mussels are highly selective grazers, showing preference for cryptophytes and diatoms in the nanoplankton size range and avoidance of most cyanobacteria, particularly Microcystis. This information coupled to our measurements of mussel abundance showed that mussel selective grazing potentially has an appreciable impact on seasonal succession of plankton groups. Parallel experiments on nutrient excretion showed the mussels have relatively constant C:N:P ratios in their tissues and that ammonium and phosphate excretion were highly correlated with ambient chlorophyll concentrations and assimilation rates of C,N, and P. Nutrient excretion was not a major contributor to the nutrient pool except for ammonium during summer when cyanobacteria dominated.

K. Varma, Florida Atlantic University, Department of Electrical Engineering; G. Sklivanitis, D. Pados, Florida Atlantic University, Computer and Electrical Engineering and Computer Science. **Training robust neural networks for autonomous plankton classification**.

Monitoring and characterization of plankton species abundance and distribution in both freshwater and marine environments around the world is key for forecasting harmful algal bloom events. We leverage reconstructed imagery from a novel submersible holographic system to test a novel data conformity evaluation tool for robust training of neural networks toward high-confidence classification of plankton. Manual labeling of the entire plankton dataset with the appropriate class is often prohibitively costly, therefore the dataset may contain mislabeled instances. We propose an algorithm based on L1-norm principal-component analysis to evaluate the conformity of labeled plankton data sets. We carry out experiments with four classes of plankton that may contain images with wrong labels. We show that autonomous conformity evaluation of the training data identifies and removes inappropriate class instances from the training set and drastically improves the classification accuracy of a convolutional neural network.

E. Verhamme, J.F. Bratton, G. Cutrell, LimnoTech; M.B. Herzog, Cleveland Water Alliance. **The $500 Observing System: Testing New Tech in Ohio**.

As scientists we know that we can't be everywhere all the time, so we need to rely on sensors to monitor the environment. Sensors allow us to document systematic change, look for short or long term signal responses, test hypothesis, and pass on our understanding of present conditions to future scientists and managers. Traditionally only a few companies specialized in manufacturing sensors designed to monitor the environment which often involve low volume production runs and 10+ year long product life cycles. Spill-over from the transportation, healthcare, home automation and other sectors has driven a large increase in significantly lower cost sensors to the market that could be available for scientists and other water-based decisions makers. This presentation will walk through a demonstration project conducted for the Ohio DNR to procure, configure, and test a subset of sensors to monitor water level, temperature, wind speed, soil moisture, turbidity, conductivity and nutrients. Sensors were deployed in the Old Woman Creek NOAA-NERRS estuary site alongside more expensive sensors.

A. Vodacek, Rochester Institute of Technology, Chester F. Carlson Center for Imaging Science; K.O. Obiero, KENYA MARINE AND FISHERIES RESEARCH INSTITUTE, Research; P. Plisnier, University of Liege, Chemical Oceanography Unit; J. Malala, Kenya Marine and Fisheries Research Institute, Turkana Station, Fisheries Department; A. Getahun, Addis Ababa University, Department of Zoological Sciences. **Long-term analysis of Lake Turkana surface temperature and turbidity using Landsat data**.

Like other African Great Lakes (AGL) and the North American Great Lakes, Lake Turkana is simultaneously facing changing environmental conditions and human pressures. The long-term Landsat satellite data record of the lake can help put into context the current status relative to conditions back to the 1980s. As a remote desert lake, there is a lack of infrastructure, which limits access to the lake so remote sensing can play a key monitoring role. Further, Lake Turkana frequently has little cloud cover and the Landsat data record is relatively complete for both reflective and thermal data. We use a prior study that examined MERIS data to ensure we select images that capture the seasonality of the lake and the long-term changes. Consistent with the initial defining stages of the monitoring program envisioned for the AGL, our analysis is limited to surface temperature and turbidity as these are easily measured and comparable to the sparse existing data record obtained through lake sampling. These results will be discussed with respect to implications for future analyses of chlororphyll with satellite data.

C.A. Volpano, University of Wisconsin MAdison, Geoscience; L. Zoet, J. Rawling, University of Wisconsin-Madison; E. Theuerkauf, Michigan State University, Dept, of Geography, Environment, and Spatial Sci. **Hydrodynamic modelling of storm impacts on a sandy beach: Point Beach State Forest, Lake Michigan**.

Lake Michigan experiences storms similar in magnitude to those on oceanic coasts. Hydrodynamic modelling is commonly used to address questions of storm impacts on erosion for oceanic coasts but is not often used in the Great Lakes. A sustained period of higher-than-average water level has caused increased erosion along the Lake Michigan coast and called attention to the lack of predictive tools for coastal management. To address this shortcoming we quantify the ability of an open source coastal modelling program for predicting changes to shoreline morphology. First, we utilize UAS for topographic surveys and a 200 kHz single-beam echosounder to collect nearshore bathymetry. Then we install pressure transducers to record nearshore wave characteristics and to constrain wave data available from GLCFS. Finally, these datasets are used to initialize an Xbeach hydrodynamic simulation to predict geomorphic change. Morphological change measured between two surveys conducted approximately 1 month apart is then compared to model outputs. With the constrained hydrodynamic model, geomorphic change can be predicted for future storm and water level conditions.

W

A. Wagh, Michigan Technological University; P. Xue, Michigan Technological University, Civil & Environmental Engineering; Y. Wang, Michigan Technological University; C. Huang, Michigan Technological University, Civil & Environmental Engineering; Y. Yang, Michigan Technological University. **Using Long short-term memory networks to improve hydrodynamic modeling**.

The Laurentian Great Lakes region is one of the most prominent hotspots where lake surfaces have warmed more rapidly than the ambient air during the summer. Lake surface temperature (LST) has been widely used as an important metric to assess climate impact in the Great Lakes. Although significant advancements of 3D hydrodynamic models for the Great Lakes have been made since the nineties, challenges remain due to errors in model representation of physical processes, boundary conditions, or forcing terms. Further improvement in simulating the lake's physical conditions is highly desired. While mechanistic models focus on improving the representation of physical processes, this study explores the possibility of using the deep learning method to improve the simulation and prediction of LST. Results show that even trained with limited observational data of atmospheric and lake variables, the long short-term memory (LSTM) network can effectively improve the accuracy of LST simulation.

M. Wakjira, Jimma University, Department of Biology; A. Getahun, Addis Ababa University, Department of Zoological Sciences. **Fish diversity and Fisheries of Omo-Turkana Basin in the face of hydrological modifications**.

The Omo-Turkana Basin spans a large part of southwestern Ethiopian highlands and northern Kenya, and consists of the Omo River and a northern portion of Lake Turkana. It is undergoing a period of rapid environmental and social changes, principally in response to the development of hydropower dams and sugarcane plantation on Omo River, consequently transforming the river's regime and its input to Lake Turkana. Nevertheless, the basin lacks full scientific documentation on its fish diversity and fisheries. The main purpose of this study was to assess fish diversity, socio-economic aspects, and related problems of the basin fisheries for better management and sustainable use of the resources. Our present survey supplemented with verified historical data provides an annotated list of 69 native species, for the basin within the Ethiopian limit, out of the 79 total for the Turkana Basin. Despite their considerable socio-economic benefits, the basin fisheries face a number of challenges. Detailed analysis of the problems and viable recommendations have been made to sustain the fisheries contributions.

H. Walsh, U.S. Geological Survey; S. Rafferty, Pennsylvania Sea Grant College Program; A. Sperry, V. Blazer, USGS. **Reproductive Health and Endocrine Disruption in Smallmouth Bass from the Lake Erie Drainage**.

In this study, smallmouth bass were collected in May 2016 from three sites in the Lake Erie drainage and from an out-of-basin site in the Allegheny River drainage. Bass were sampled for histopathology and pieces of liver and testes were preserved for transcript abundance analysis with the Nanostring nCounter® technology. Evidence of endocrine disruption was assessed by testicular oocytes (TO) and analysis of plasma vitellogenin (VTG) in male fish. Additionally, transcript abundance of 17 liver transcripts associated with reproduction, endocrine activity, and contaminant detoxification and 40 testes transcripts associated with male and female reproduction, germ cell development, and steroid biosynthesis was assessed. The results showed males with a high rate of TO (87-100%) and VTG and numerous transcripts that were differentially regulated between the four sites. At sites with the greatest amount of agriculture and development, TO prevalence and severity was the highest. Transcript abundance was variable; however, those associated with female reproductive function were greater in males at sites with high agriculture and development.

Y. Wang, A. Ebers Broughel, J. Hochheimer, Tetra Tech, Environmental Services. **Opportunities in predictive modeling and distribution analysis enabled by continuous monitoring**.

Advances in in-situ monitoring allow compilation of rich datasets that offer new policy-relevant insights. Based on high-frequency water quality and weather data from USGS & NOAA, this research utilizes different predictive models to identify anomaly events and to predict algal peaks before they occur. With a Monte Carlo simulation, this research compares different sampling regimes, aiming to determine the best sampling time to capture diurnal peaks and minima in water quality parameters. We investigated the optimal sampling frequency, comparing weekly, daily, and sub-daily sampling options. Rich datasets also allow the determination of true distributions of water quality parameters. Comparing growing and non-growing seasons and monthly data, we have considered the goodness of fit for five distributions (log-normal, generalized extreme value, Gumbel, Weibull, Gamma). These analyses provide a better understanding of the underlying ecological processes and allow for improved management practices.

J. Wang, Argonne national laboratory; P. Xue, Michigan Technological University, Civil & Environmental Engineering; Z. Yang, Y. Qian, Pacific Northwest National Lab. **Impacts of Great Lakes on warm season precipitation using high resolution simulations**.

Great Lakes can influence the warm-season precipitation in many ways. In the spring and early summer, lake temperatures are still cooler than the atmosphere aloft. This tends to decrease convective available potential energy, hence weakening mesoscale convections. In late summer, the temperatures of the lake and the atmosphere reach an equilibrium, but the Great Plain low-level jet is still present, which may make the mesoscale rainstorm more persistent. This study investigates the lake-effect warm-season precipitation by designing weather research and forecasting (WRF) experiments. In one experiment, we couple the one-dimensional (1-D) lake (WRF-Lake) model into WRF; in the other simulation, we do not couple with the 1-D WRF-Lake, but replace the skin temperature over the Great Lakes using observational lake surface temperature. We are able to address several questions, for example, how the lakes affect the onset and the duration of the rainstorms in spring, summer, and early fall? Whether the lakes change the intensity and the size of the rainstorms? Is the 1-D lake mode sufficient to capture the lake effect on the warm season rainstorms?

C. Wardlaw, University of Western Ontario, Biology; P.L. Corcoran, University of Western Ontario, Earth Sciences; B. Neff, Western University, Biology. **Microplastics in white sucker (Catostomus commersonii) and common carp (Cyprinus carpio) from the Thames River, ON**.

Rivers are known to act as a depositional sink and transport mechanism of microplastic (MP) pollutants to lakes and oceans. However, few studies have conducted analyses in tributaries feeding into the Great Lakes. As well, limited data are available regarding MP ingestion in both riverine and demersal groupings of fish. The goal of this study is to investigate a potential connection between MP levels in sediment and ingestion by riverine demersal fish. Building on a previous study on MPs in benthic sediment from the Thames River, ON, 15 white sucker along with opportunistic capture of common carp were collected from 11 locations in the Upper Thames River. The gastrointestinal tract of fish were digested using 20% KOH and filtered after 48 hours. Microplastics were visually characterized by shape, colour and size using a stereomicroscope, and analyzed using Fourier Transform Infrared Spectroscopy. Preliminary results found 0 to14 MP particles per individual white sucker, and 3 to 60 particles total per site. Fish from urban areas contained higher MP abundances, aligning with previous findings regarding urban land use as a contributing source of MPs to inland waters.

J.M. Watkins, L. Rudstam, Cornell University, Natural Resources; J.K. Connolly, Cornell Biological Field Station, Department of Natural Resources and the Environment; C. Marshall, Cornell University, Dept. of Natural Resources and the Environment; E.A. Whitmore, Cornell University Bio Field Station, Dept. of Natural Resources and the Environment; S. Figary, Cornell University, Natural Resources; R. Barbiero, CSRA; A.E. Scofield, US Environmental Protection Agency, Great Lakes National Program Office. **Oligotrophication of the Great Lakes - the zooplankton perspective**.

Zooplankton are a major food source for the main prey fish species supporting the Great Lakes salmonid sport fishery. We compare temporal trends in the zooplankton communities of lakes Ontario, Michigan, Huron and Superior using data from the Great Lakes National Program Office annual sampling in April and August. Over the last 24 years, zooplankton species composition of lakes Ontario, Michigan and Huron changed towards the species composition in Lake Superior. This includes increasing numbers of large cold-water calanoid copepods, fewer cladocerans, and fewer smaller cyclopoid copepods. We explore potential explanations for the observed trends in zooplankton, including increased water clarity, which promotes the deep chlorophyll layer (DCL) and the large calanoid copepods that feed on DCL phytoplankton, decreased phosphorus concentrations in the offshore, changes in alewife abundance affecting zooplankton size structure, and changes in invertebrate predators like the spiny waterflea.

C.G. Weisener, University of Windsor, Great Lakes Institute for Environmental Research; S.O. Mundle, University of Windsor, Great Lakes Institute for Environmental Research (GLIER). **WITHDRAWN: Developing a chemical/bioindicator tool box" for Greenhouse Storm Water Pond Nutrient Management"**.

The Leamington Tributaries are unique in the Canadian Lake Erie watershed with respect to the concentration and spatial extent of Greenhouse operations which have more than doubled from 2011-2020. The elevated nutrient concentrations from greenhouses storm water retention ponds is considered to be a potential source of nutrients in the region. Identifying and monitoring nutrient retention within the ponds is critical to mitigating their impact on the watershed. This presentation describes a cooperative research program between the Ontario greenhouse vegetable grower (OGVG) and the University of Windsor. Several ponds were identified based on historical nutrient data, pond age, size, and other former modifications (e.g., dredging). This research program is focused on causal switchover of sediments in retention ponds from a nutrient 'sink' to 'source' monitoring of the physical, chemical and biological (microbial consortium) processes occurring in their retention ponds of concern identified by OGVG. The information presented will be used to inform and develop sustainable management practice for water retention ponds in this billion-dollar sector

L.A. Weller, University of Windsor, Great Lakes Institute for Environmental Research; C.M. Febria, University of Windsor, Great Lakes Inst. for Env. Research (GLIER) & Dept. of Integrative Biology; J.D. Hosen, Perdue University; C. Proctor, University of Windsor. **CHARACTERIZING CARBON COMPLEXITY ACROSS THE LAND-WATER INTERFACE IN AGRICULTURAL LANDSCAPES**.

Carbon may be a key underexplored factor in nutrient management in the Great Lakes basin. Landscape-level characteristics greatly influence the quantity and quality of dissolved organic matter (DOM) exported into freshwater ecosystems. Light-emitting fluorescent fractions of DOM (FDOM) have been linked to broad land-use categories. However, using FDOM to characterize carbon in agricultural landscapes with respect to practices that build soil health remains largely unexplored. Using the low-topography, clay-dominated soils of Essex County, southern Ontario, as a case study we conducted a field survey to characterize DOM across the land-water interface. We used FDOM as a tracer across a suite of farm-based agricultural practices related to carbon. Here we discuss the farmer-centered approach taken to implementing the field study and show preliminary results. This is especially critical in the Great Lakes basin, where farm-based measures are primarily focused on P-management. By examining DOM in the context of other macronutrient cycles our work may provide critical insight into the realities of implementing regional policy and management.

E.A. Whitmore, Cornell University Bio Field Station, Dept. of Natural Resources and the Environment; J.K. Connolly, Cornell Biological Field Station, Department of Natural Resources and the Environment; J.M. Watkins, L. Rudstam, Cornell University, Natural Resources. **New Monitoring and Detection Methodologies for the Lake Ontario Benthic Cladoceran Community**.

Planktonic cladocerans are well studied, however little is known about cladocerans that live primarily in the benthos of the Great Lakes, and the limited information available is from the nearshore. Establishing the base-line structure of a community can help managers assess how an invasion can influence a community. In 2018, 26 Lake Ontario stations were sampled with benthic ponar grabs to focus on meiobenthos. The stations sampled ranged in depth from 0.1-185 meters. Out of the 26 stations sampled, 19 had benthic cladocerans. Benthic cladocerans were found at stations as deep as 62 meters, substantially deeper than previously believed. After animals were identified through traditional taxonomic means they were sent to BOLD for CO1 gene barcode

analysis. Lake Ontario had 16 different species from 6 different genera. The genetics were then compared to other known genetic samples and in some cases used to build a new genetic library for previously unknown species. Using the traditional taxonomy and genetics combined we can more accurately monitor benthic Cladocera and detect potential invasive cladoceran species in the benthos.

D. Wiitala, North Jackson Company. **Groundwater levels and stream baseflow in Marquette County, Michigan during changing climate**.

Groundwater levels in glacial aquifers connected to streams in Marquette County Michigan have been monitored for several decades for environmental assessment of mining projects and community water supply. These data viewed alongside stream discharge hydrographs reveal the degree to which groundwater connection to surface water provides remarkably stable baseflow to streams and therefore input to Lake Superior. Lake and groundwater elevation fluctuations show similar patterns that are closely linked to hydroclimatic oscillations and are sensitive to large scale changing climate. Stream baseflow may not exhibit the same fluctuation patterns in watersheds where stream baseflow is greater than 90% supported by groundwater input.

K.C. Williams, USEPA Office of Research and Development, Great Lakes Toxicology and Ecology Division; P. Seelbach, University of Michigan, School for Environment and Sustainability; M. Baumann, The Pennsylvania State University, Department of Geography. **Social and organizational dimensions of Great Lakes remediation, restoration, and revitalization**.

Emerging research suggests that remediation, restoration, and community revitalization (R2R2R) work includes processes that are intensely local and cooperative. Lessons from ecosystem and integrated water resources management indicate that effective local groups and governments are necessary for delivery of ecosystem-scale management programs. The Great Lakes Restoration Initiative has kicked-off an experiment where agencies, communities, organizations, and individuals are together engaged in program delivery of R2R2R. Until now, little research has examined the social and organizational dimensions of local efforts and is the subject of an upcoming special section of the Journal of Great Lakes Research. The impact will be to bridge community, technical, and research knowledges. The Call for Papers will be open from April - June 2020 and may catalyze a network of social and organizational scientists who work alongside biophysical scientists towards successful R2R2R. To help start a conversation, we will keep our presentation short to allow time for questions and discussion.

M.J. Windle, M. Perron, River Institute; K. Schwartz, Bishop's University; J. Ridal, River Institute. **Downstream expansion of the tubenose goby (Proterorhinus semilunaris) in the St. Lawrence River**.

The tubenose goby (*Proterorhinus semilunaris*) is an invasive species of fish that was first documented in the St. Lawrence River in 2011, and that has consistently been documented by surveys in the Thousand Islands section of the river since 2016. Here we report on a significant range expansion of this species, involving a 80km downstream distribution shift in the St. Lawrence River between 2019 and 2020. Local abundance of this species at regularly monitored sites was also significantly higher in 2020 compared to previous years. We include an analysis of fish communities and habitat characteristics of sites where tubenose goby have been found, and discuss implications for the St. Lawrence River ecosystem.

M.M. Woller-Skar, A. Locher, Grand Valley State University, Biology; E. Audia, Iowa State University, Natural Resource Ecology and Management; E.W. Thomas, Waubonsee Community College, Biology. **Changing water levels in Lake Superior impact periphytic diatoms**.

As Lake Superior lake levels change, variable offshore geology in the Keweenaw Peninsula is differentially exposed and inundated. The purpose of our project was to predict how periphyton communities would respond to shifts in substrate geology and degree of inundation with changing water levels in the Keweenaw Peninsula. We compared periphyton communities based on depth and geology and collected high-resolution bathymetry to quantify surface area of habitat under different climate scenarios. Our results suggest that substrate geology influenced periphyton community assemblages. A predicted decrease in water levels of 0.63 m resulted in a loss of available surface area for periphyton habitat by 600 to 3000 m2 per 100 m of shoreline with slopes ranging 2 to 9°. If water levels rise, the surface area of substrate will increase by 150 to 370 m2 per 100 m of shoreline, as the slopes above current lake levels are steeper (8–20°). Changes in the surface area of the substrate due to fluctuating water levels will likely result in a shift in species composition, which could alter the structure of aquatic food webs and ecological processes.

H.L. Elmer, K. Brewster, Chagrin River Watershed Partners; B. Kerkez, B.P. Wong, Hyfi, LLC. **IoT for watershed management and planning: a case study from the Cleveland Metro Region**.

Urban flooding poses an ever-growing challenge across metro Cleveland and greater Northeast Ohio. Increased development paired with intensifying rainfalls contribute to more flooding and erosion -- putting people, businesses, and infrastructure at higher risk. A new generation of sensing technologies, which fall under the umbrella of the Internet of Things (IoT), promises to usher in an era of data-driven management. The Chagrin River Watershed Partners, together with their partners and member communities, have deployed real-time, Internet-connected sensors to closely monitor over one thousand square miles. Nearly 60 new locations are now reporting water levels and alerts directly to community members. We introduce the wireless monitoring network and share the initial results with a focus on the value of the data for enhanced flood warnings, watershed planning, and recreation.

J. Wu, S. Wu, B. Jin, Nanchang University. **Analysis on the composition of by-catch in crayfish long trap nets in Poyang Lake**.

The red swamp crayfish (Procambarus clarkii), one of the world's most successful aquatic invaders, is now common throughout the middle and lower Yangtze River basin. In the Dongting and Poyang floodplain lakes, crayfish is the most important fishery component during the summer flood season. Long trap nets are the main fishing gear used to catch the red swamp crayfish. The traps catch crayfish and many other aquatic organisms, and there is a lack of understanding regarding this gear's efficiency. For assessing the efficiency of long trap nets in fishing red swamp crayfish and the by-catch of the red swamp crayfish, this study selected samples from sublakes and rivers of the Poyang Lake in summer 2019. The results show that the selectivity of trap nets was low, and many by-catches were produced, the red swamp crayfish achieved a ratio of more than 55 times more. A large number of larvae of local species were captured Based on the results, we recommend: 1) Strictly control the fishing period and strictly prohibit fishing.; 2) Improve fishing gear structure to reducing the production of by-catch.

X

Z. Xia, Great Lakes Institute for Environmental Research, University of Windsor; H. MacIsaac, University of Windsor; R.E. Hecky, .University of Minnesota-Duluth, Biology Department and Large Lakes Observatory; D.C. Depew, Environment and Climate Change Canada, Watershed Hydrology and Ecology Research Division; G.D. Haffner, Great Lakes Institute for Environmental Research University of Windsor; P. Weidman, University of Windsor, Great Lakes Institute for

Environmental Research (GLIER). **Multiple factors regulate filtration by invasive mussels: implications for whole-lake ecosystems**.

High clearance rates (CR) and dense populations underpin ecological impacts of the quagga mussel (Dreissena rostriformis bugensis). CRs are highly variable as are environmental factors that regulate them. We investigated CRs of quagga mussels under varying conditions including water temperature, food availability, habitat depth, flow velocity, and duration of incubation in chambers with both static and flowing water. We found that CRs were positively related to water temperature and initial food concentration in static chambers. Mussels from deeper water (20 m) had higher CRs than shallower water (2–10 m) and CRs were inversely affected by total mussel dry weight. Flow rates generated a unimodal pattern of CR with optimal rates of 6-12 cm s-1. Enhanced flow velocity (22 cm s-1) significantly increased the closing/reopening activity of mussel valves. Incubation time had a strong negative effect on CRs. Our findings highlight how multiple factors can influence quagga mussel CRs by factors of 2–10×. Given widespread habitat heterogeneity in large aquatic ecosystems, whole-lake estimates of mussel impacts should include multiple regulatory factors.

S. Xu, S.K. Frey, A.R. Erler, O. Khader, S.J. Berg, H. Hwang, M. Callaghan, Aquanty Inc.; J.H. Davison, Aquanty, School of Engineering; E.A. Sudicky, Aquanty Inc. **Modeling Direct Groundwater Discharge into the Laurentian Great Lakes**.

A fully-integrated surface water-groundwater model has been developed for the entire Laurentian Great Lakes basin, in order to investigate direct groundwater discharge into the Great Lakes. Annual average rates of direct groundwater discharge to Lakes Superior, Michigan, Huron, Erie and Ontario through the lakebed and nearshore region are predicted to be 29.0, 38.6, 24.5, 11.9, and 11.6 m^3/s, respectively. Relative to positive basin supply, direct groundwater discharge ranges from 0.6% for Lake Ontario to 1.3% for Lake Michigan (0.8% on average for all lakes). Simulation results show that the direct groundwater discharge varies seasonally, driven by fluctuations in both lake levels and nearshore terrestrial groundwater levels, and also spatially due to different hydraulic properties of the local hydrostratigraphic units. In this presentation general model performance and spatio-temporal characteristics of groundwater discharge will be discussed.

C. Huang, P. Xue, Michigan Technological University, Civil & Environmental Engineering; E.J. Anderson, NOAA, Great Lakes Environmental Research Laboratory; Y. Liu, One Concern; G. Mann, NOAA, NWS. **Modeling the coastal flooding: a study case in Ludington, Michigan**.

Various mechanisms, including meteotsunamis, can cause coastal flooding in the Great Lakes. On April 13, 2018, a high-amplitude atmospheric inertia–gravity wave packet caused a set of meteotsunami waves that struck the shores near Ludington, Michigan. During the event, harbor walls were overtopped, damage occurred to shoreline homes and boat docks. While the present Lake Michigan-Huron Operational Forecast System (LMHOFS) captured this event, the model was not able to resolve the resulting coastal flooding. This study revisits the April 2018 Ludington meteotsunami with a newly developed hydrodynamic model that resolves coastal engineering structure and wetting and drying features in the low-lying land. The model successfully resolved the meteotsunami-induced coastal flooding. Impacts of several factors on the flooding are examined, including model resolution, model mesh extension to land, coastal engineering structure, water level change, and atmospheric pressure perturbation. The improved results suggest the need for an enhanced operational infrastructure for coastal hazard and meteotsunami forecasting in the Great Lakes.

P. Xue, C. Huang, Michigan Technological University, Civil & Environmental Engineering; M. Notaro, University of Wisconsin-Madison, Nelson Institute Center for Climatic Research; Y. Zhong, University of Wisconsin-Madison; C. Peters-Lidard, C. Cruz, E. Kemp, NASA Goddard Space

Flight Center; D. Kristovich, University of Illinois at Urbana-Champaign; M. Kulie, NOAA/NESDIS/STAR/ASPB; J. Wang, University of Illinois at Urbana-Champaign; S. Vavrus, University of Wisconsin-Madison; J. Wang, Argonne national laboratory; Y. Qian, Z. Yang, Pacific Northwest National Lab. **Assessment of the two-way coupling of FVCOM and NU-WRF in the Great Lakes Region**.

The world's largest freshwater system, the Laurentian Great Lakes, holds significant environmental, cultural, and economic value for both the region and the nation. They are not only sensitive to regional climate but also a significant regional climate driver. Regional climate models (RCMs) are commonly used for assessing and predicting climate impact. However, RCMs for the Great Lakes region were often configured to be coupled with 1-D column lake models to represent the lake hydrodynamics and lake-atmosphere interaction. Such 1-D models have limitations in resolving the Great Lakes' physical processes due to their sheer size and sea-like characteristics. In this study, NU-WRF is two-way coupled with FVCOM to assess regional climate impact over the Great Lakes region, aimed at improving the representation of the coupled atmosphere-lake-ice system. Results are discussed focusing on identifying the 1D vs. 3D hydrodynamic model's strengths and weaknesses in simulating the coupled system.

Z. Yang, Y. Qian, Pacific Northwest National Lab; J. Wang, Argonne national laboratory; P. Xue, Michigan Technological University, Civil & Environmental Engineering; W. pRINGLE, Argonne national laboratory. **Convection Systems and Summer Storms over the Great Lakes Region**.

While the largest form of deep convective storms, known as mesoscale convective systems (MCSs) play a key role in the hydrological cycle of the Great Lake Region (GLR), the locally-driven isolated deep convections (IDCs) also contribute to a large fraction of the GLR precipitation. This study intends to quantify the relative contribution of MCSs and IDCs to the precipitation over the GLR region. Based on 14-year of observation data, we use a tracking algorithm to explicitly track the growth and propagation of IDCs and MCSs near the GLR. Our preliminary results show that while IDC is more locally driven, about 75% of the MCSs are initiated from outside the GLR and later propagate to the GLR and the rest 25% are initiated locally. We intend to identify the large scale meteorological patterns (LSMPs) associated with the IDCs and MCSs and understand the favorable synoptic conditions for the formation of these systems from the dynamic and thermodynamic perspectives.

X. Ye, Michigan Tech University, Civil Engineering; P. Xue, Michigan Technological University, Civil & Environmental Engineering; P. Chu, E.J. Anderson, L. Mason, NOAA, Great Lakes Environmental Research Laboratory. **Improved lake surface temperature analysis in Lake Michigan through data assimilation**.

The lake surface temperature (LST) of the Great Lakes is an essential metric for understanding regional climate and climate impacts on the hydrologic system. The Great Lakes Surface Environmental Analysis (GLSEA2) is a valuable LST data source. In this study, the GLSEA LSTs are assimilated into a 3-D hydrodynamic model to improve LST accuracy from two aspects: 1) the new LST dataset has a higher temporal resolution from daily to hourly. 2) the new LST data resolves the local upwelling events, shown as a narrow strip of cold water close to the shore, which is often missed in the GLSEA2 LST dataset. Assimilation performances are discussed, focusing on the influences of lake physical processes, assimilation schemes, and observation data availability.

Y

D.J. Young, Trent University, Graduate Studies. **Sturgeon thunder: Integrating western science and indigenous knowledge to save a species in peril**.

Lake Sturgeon were one of the most abundant species within their historical range, but in the last century have experienced drastic declines in abundance. This is largely due to anthropogenic activity, such as alteration/fragmentation of waterways, over exploitation, and mismanagement. Thus, Lake Sturgeon are listed as 'Threatened' under COSEWIC, with some populations even considered as 'endangered'. Considering their importance ecologically, culturally, and socially to First Nations, there is ongoing multi-national research to address knowledge gaps regarding Lake Sturgeon. The St. Mary's and Garden Rivers are home to a remnant Lake Sturgeon population, which is being studied collaboratively using Western Science methods and Indigenous Knowledge. This presentation highlights the advantages of collaborating Western Science and Indigenous Knowledge, and why using this approach is beneficial to environmental research and critical for the effective management of natural resources.

B. Young, NEW Water. **Water quality responses to agricultural BMP implementation in the Silver Creek conservation study**.

The introduction of excessive sediment and nutrients have historically degraded the water quality of Green Bay, leading to dangerous algal blooms, zones with depleted oxygen and habitat loss. In 2014, NEW Water, the brand of the Green Bay Metropolitan Sewerage District began testing a multi-year alternative compliance option to reduce unregulated, non-point sources of sediment and nutrients in the predominately agricultural Silver Creek watershed. One main goal of the pilot study is to better understand instream water quality response to the implementation of a variety of practices. Changes in water quality resulting from BMP implementation are being monitored through grab sample analysis at 5 sites along the mainstem of Silver Creek coupled with automatic sampling that characterizes storm flow, concentrations, and loads. Pre and post BMP implementation water quality trends vary spatiotemporally, but phosphorus reductions are becoming more evident, even with historical precipitation and flows in 2018 and 2019. Lessons learned in Silver Creek are driving NEW Water's full scale watershed program in neighboring Ashwaubenon and Dutchman Creeks.

J.T. Yu, University of Toronto, Department of Earth Sciences; P. Helm, Ontario Ministry of the Environment, Conservation and Parks, Environmental Monitoring & Reporting Branch; M.L. Diamond, University of Toronto, Dept of Earth Sciences & School of the Environment. **Sources of microplastics in nearshore surface waters of the Great Lakes**.

Microplastics enter lakes from numerous sources which are not well understood. The goal of this study is to quantify and categorize microplastics found in surface waters of Lakes Ontario, Erie and Superior to inform on sources. Sixty-two samples were collected using manta trawls and microplastics are categorized using a source-specific categorization scheme. Preliminary results show wide spatial variability, with abundances ranging from 25,000 - 2,290,000 particles/km^2 in Lake Ontario and 27,000 - 359,000 particles/km^2 in Lake Erie. Highest abundances were found at sites near the Greater Toronto Area, dominated by fragments (45%) and irregular microbeads (20%) that are usually found in facial cleansers and cosmetics. Eighteen % of particles had similar twisted, curled, or droplet-like characteristics. These particles are consistent with manufacturing and moulding processes, suggesting they originate from commercial activities. Polymer analysis is performed on a subset of particles using micro-FTIR. This study improves our understanding of sources to help target local source-specific reduction efforts in the Great Lakes.

Z

J.A. Zalusky, A. Huff, S. Katsev, T. Ozersky, University of Minnesota-Duluth, Large Lakes Observatory. **Survival, Nutrient Recycling and Tissue Composition of Profundal Quagga Mussels during starvation**.

The quagga mussel, *Dreissena rostriformis bugensis*, has invaded large portions of the Great Lakes. To better understand the ability of quagga mussels to colonize and survive in profundal habitats, we investigated the effects of starvation on quagga mussels under laboratory conditions. In an 8-month trial, we compared survival, growth, tissue elemental composition as well as respiration and nutrient recycling rates of starved mussels and of mussels fed a high-quality diet. Our results indicate that quagga mussels are highly starvation tolerant at temperatures characteristic of the hypolimnia of the Great Lakes, with >90% survival after 231 days of starvation. Starved mussels had lower respiration and excretion rates of P and N, but not lower biomass or tissue P compared to well-fed mussels. We show that quagga mussels are highly resilient to disruptions in food supply, which helps explain their invasion success in the cold and food-limited profundal zone of the Great Lakes.

A. Zastepa, Environment and Climate Change Canada, Canada Centre for Inland Waters; T. Miller, University of Wisconsin - Milwaukee, School Of Public Health; L. Watson, Environment and Climate Change Canada; H.J. Kling, Algal Taxonomy & Ecology Inc., Algal taxonomy; S.B. Watson, Trent University, School of Graduate Studies, Environmental and Life Sciences. **Toxic and other bioactive metabolites in deep chlorophyll layers of Planktothrix in Georgian Bay, Lake Huron**.

We document and characterize deep chlorophyll layers (DCLs), present as dense, thin, metalimnetic plates dominated by the large, potentially toxic, and bloom-forming cyanobacteria Planktothrix isothrix, occurring nearshore in 2 of 15 embayments surveyed along Georgian Bay, Lake Huron. Dominance of P. isothrix increased with stratification, reaching up to 65% of biomass (3.5 mg/L) as deep as 10 m. Presence of opposing and intersecting vertical gradients of light and nutrients was consistent with similar systems with DCLs. However, co-occurrence of metal-oxidizing bacteria Leptothrix spp. as well as bactivorous flagellates indicates a role for microbial processing of the hypolimnetic nutrients, specifically P and Fe. DCLs had cyanobacterial toxins microcystins (peak 0.4 ug/L) as well as metabolic inhibitors anabaenopeptins (peak 7 ug/L) and cyanopeptolins (peak of 1 ng/L) (and genes). We conclude that hypoxia-driven internal loading of nutrients from sediments facilitates the annual, toxigenic Planktothrix DCLs but that microbial processes and allelopathy act as modulating factors of phytoplankton composition and function.

N.D. Zgnilec, OHM Advisors, Environmental Water Resources Group. **Exploring Techniques for Continuous, Real-Time Bacteria Monitoring in Southeast Michigan**.

The Clinton River Watershed comprises the northern third of the Detroit Metropolitan Area and is the largest USA tributary to Lake St. Clair. Its highly urbanized landscape creates significant stormwater-driven environmental impacts to both the river proper and its receiving lake. In response, a set of local, state, and university partners formed the Clinton River Sensor Project, with the aim of helping local water and health managers fill data gaps, developing a suite of powerful decision-support tools, and providing regional and local scientific context for collaborative stormwater management. This presentation will present the work that was completed in 2019 to explore techniques for continuous, real-time monitoring of fecal contamination across the Clinton River watershed to guide water quality management. This component of the project explored real-time, continuous monitoring of water quality using alternative fecal contamination indicators to better clarify the timing and sources of contamination in rivers.

B. Zhou, A. Lisogorsky, M.S. Hassanabadi, F.R. Nezhad, P.V. Van Cappellen, University of Waterloo, Ecohydrology Research Group. **Characterization and modeling of phosphorus cycling in urban bioretention cell under climate change**.

Phosphorus (P) loadings from urban areas exported via stormwater runoff are typically elevated compared to those associated with runoff from natural lands, and cause water quality issues such as eutrophication in aquatic systems.Bioretention cell (Bio-C) is a commonly used low impact development (LID) technology for reducing peak discharge and nutrient export from urban areas. There is still limited understanding about the P retention performance of this LID option in cold climates and during extreme hydrologic events caused by climate change. Here we aim to address this knowledge gap by developing and applying a Bio-C P reactive transport model in a research site in Mississauga, Ontario, which has been monitored for a number of years, to predict the fate and transport of P under hydrologic events of different sizes. We will subsequently incorporate an ensemble of future climate projections in our modeling framework to evaluate the influence of Bio-C on urban P cycle under climate change. This study will also provide practitioners with an understanding on how to optimize the design parameters of Bio-C to improve Bio-C's capacity for retaining P in cold regions.

M. Zischke, Purdue University, Forestry and Natural Resources; D. O'Keefe, Michigan Sea Grant; T.S. Seilheimer, Wisconsin Sea Grant. **The Impacts of COVID-19 on the Charter Fishing Industry in Lake Michigan**.

The COVID-19 pandemic has had huge implications to communities and economies across the United States. One industry that has been uniquely impacted by the pandemic is charter fishing on Lake Michigan. To assess the impacts of COVID-19 on charter fishing businesses, we conducted mail and online surveys of 736 charter operators licensed in Wisconsin, Illinois, Indiana and Michigan. Of the 217 (29.5%) respondents, 35% had canceled all fishing trips between March and June due to COVID-19, while others conducted 15-23 less trips than they did in 2019. Most operators resumed some fishing activity between July and October, but 50% of operators still reported a reduction in bookings for the 2021 season. On average, individual operators lost $10,000-$15,000 in revenue during 2020, resulting in at least $8 million in lost revenue across the fishery due to COVID-19. Operators also reported laying off staff and some expected to lose their business in the next 6-12 months. These results may lead to the development of specific assistance and training programs for charter fishing businesses in Lake Michigan.